Documentation Release Date: January 27, 1998

3.2. FIBER PLACEMENT

3.2.1. Fiber Feeder Structure Fractions

Definition: The relative amounts of different structure types supporting fiber feeder cable in each density zone. Aerial feeder cable is attached to telephone poles, buried cable is laid directly in the earth, and underground cable runs through underground conduit. HM 5.0a may adjust the input values based on the buried fraction available for shift parameter using the process described in Section 2.5.2.

Default Values:

Fiber Feeder Structure Fractions				
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)	Buried Fraction Available for Shift
0-5	.35	.60	.05	.75
5-100	.35	.60	.05	.75
100-200	.35	.60	.05	.75
200-650	.30	.60	.10	.75
650-850	.30	.30	.40	.75
850-2,550	.20	.20	.60	.75
2,550-5,000	.15	.10	.75	.75
5,000-10,000	.10	.05	.85	.75
10,000+	.05	.05	.90	.75

Support: *{NOTE: Excerpts from the discussion in Section 2.5. [Distribution] are reproduced here for ease of use.}*

It is the opinion of outside plant engineering experts that density, measured in Access Lines per Square Mile, is a good determinant of structure type. That judgment is based on the fact that increasing density drives more placement in developed areas, and that as developed areas become more dense, placements will more likely occur under pavement conditions.

Aerial/Block Cable:

"The most common cable structure is still the pole line. Buried cable is now used wherever feasible, but pole lines remain an important structure in today's environment."[1]

Where an existing pole line is available, cable is normally placed on the existing poles. Abandoning an existing pole line in favor of buried plant is not usually done unless such buried plant provides a much less costly alternative.

Buried Cable:

Default values in HM 5.0a reflect an increasing trend toward use of buried cable. Since 1980, there has been an increase in the use of buried cable for several reasons. First, before 1980, cables filled with water

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[1] Bellcore, *BOC Notes on the LEC Networks - 1994*, p. 12-41.

blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons.

Underground Cable:

Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Any conduit runs short enough to not require a splicing chamber or manhole are classified to the aerial or buried cable account, respectively.

Buried Fraction Available for Shift:

This input addresses the ability of the model to perform a dynamic calculation to determine the most efficient life-cycle costs of buried vs. aerial structure. The calculation considers the different values involved in buried vs. aerial structure in terms of initial investment, sub-surface conditions, soil texture, percent structure sharing, depreciation rates, and maintenance costs.

Underground conduit is not considered as a candidate for structure shifting, since the motivation for placing underground conduit and cable is usually a function of high pavement costs and the need to allow for future replacement and addition of cables without disturbing the above ground pavement conditions.

Since shifting of structure type from buried to aerial, or vice versa is permitted, the HAI Model allows the user to affect such shifting by the application of engineering judgment. There may be local ordinances or regulatory rules, that encourage utilities to place out-of-sight facilities under certain conditions. Therefore, should aerial structure be the most economic solution in a particular cable section, the model could shift all buried structure to aerial. However, in the event such shifting is not practical, the HAI Model allows the user to reserve a percentage of buried cable structure, regardless of the opportunity for a shift to less expensive aerial cable. Our outside plant engineering experts recommend that only 75% of the buried percentage be allowed to shift to aerial.

The user should note that this default value can be adjusted to 100% to allow the model to optimize the cable structure choice between aerial and buried structure without constraint.

3.2.2. Fiber Feeder Pullbox Spacing, Feet

Definition: The distance, in feet, between pullboxes for underground fiber feeder cable.

Default Values:

Fiber Feeder Pullbox Spacing, feet	
Density Zone	Distance between pullboxes, ft.
0-5	2,000
5-100	2,000
100-200	2,000
200-650	2,000
650-850	2,000
850-2,550	2,000
2,550-5,000	2,000
5,000-10,000	2,000
10,000+	2,000

Support: Unlike copper manhole spacing, the spacing for fiber pullboxes is based on the practice of coiling spare fiber (slack) within pullboxes to facilitate repair in the event the cable is cut or otherwise impacted. Fiber feeder pullbox spacing is not a function of the cable reel lengths, but rather a function of length of cable placed. The standard practice during the cable placement process is to provide for 5 percent excess cable to facilitate subsurface relocation, lessen potential damage from impact on cable, or provide for ease of cable splicing when cable is cut or damaged.[2] It is common practice for outside plant engineers to require approximately 2 slack boxes per mile.

3.2.3. Buried Fiber Sheath Addition, per Foot

Definition: The cost of dual sheathing for additional mechanical protection of buried fiber feeder cable.

Default Value:

Buried Fiber Sheath Addition, per foot
$0.20 / ft.

Support: Incremental cost for mechanical sheath protection on fiber optic cable is a constant per foot, rather than the ratio factor used for copper cable, because fiber sheath is approximately ½ inch in diameter, regardless of the number of fiber strands contained in the sheath. The incremental per foot cost was estimated by a team of experienced outside plant experts who have purchased millions of feet of fiber optic cable.

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[2] CommScope, *Cable Construction Manual, 4th Edition*, p. 75.

3.3. CABLE SIZING FACTORS

3.3.1. Copper Feeder Cable Sizing Factors

Definition: The factor by which feeder cable capacity is increased above the size needed to serve a given quantity of demand in order to provide spare pairs for breakage, line administration, and some amount of growth. Calculated as the ratio of the number of assigned pairs to the total number of available pairs in the cable.

Default Values:

Copper Feeder Cable Sizing Factors	
Density Zone	Factors
0-5	.65
5-100	.75
100-200	.80
200-650	.80
650-850	.80
850-2,550	.80
2,550-5,000	.80
5,000-10,000	.80
10,000+	.80

Support: *{NOTE: The discussion in Section 2.6.1. [Distribution] is reproduced here for ease of use.}*

In determining appropriate cable size, an outside plant engineer is more interested in a sufficient number of administrative spares than in the percent sizing ratio. The appropriate "target" feeder cable sizing factor, therefore, will vary depending upon the size of cable. For example, 75% utilization in a 2400 pair cable provides 600 spares. However, 50% utilization in a 6 pair cable provides only 3 spares. Since smaller cables are used in lower density zones, Distribution Cable Sizing Factors in HM 5.0a are lower in the lowest density zones to account for this effect.

In general, the level of spare capacity provided by default values in HM 5.0a is sufficient to meet current demand plus some amount of growth. Because the model calculates the unit loop investment cost as the total loop investment (including spare capacity), divided by the current loop demand, the resulting unit costs are a conservatively high estimate of the economic cost of meeting current loop demand. This occurs because, in reality, some of the spare copper feeder plant can and will be used to satisfy additional loop demand in the future, without causing any additional investment cost, thus a larger number of customers will pay for the cable over time. In this sense, the HM 5.0a default values for the copper feeder cable sizing factors are conservatively low from an economic costing standpoint.

3.3.2. Fiber Feeder Cable Sizing Factor

Definition: Percentage of fiber strands in a cable that is available to be used.

Default Values:

Fiber Feeder Cable Sizing Fill Factor	
Density Zone	**Fill Factor**
0-5	1.00
5-100	1.00
100-200	1.00
200-650	1.00
650-850	1.00
850-2,550	1.00
2,550-5,000	1.00
5,000-10,000	1.00
10,000+	1.00

Support: Standard fiber optic multiplexers operate on 4 fibers. One fiber each is assigned to primary optical transmit, primary optical receive, redundant optical transmit, and redundant optical receive. Since the fiber optic multiplexers used by HM 5.0a have 100 percent redundancy, and do not reuse fibers in the loop, there is no reason to divide the number of fibers needed by a cable sizing fill factor, prior to sizing the fiber cable to the next larger available size.

3.4. CABLE COSTS

3.4.1. Copper Feeder Cable: Cost per Foot, Cost per Pair-Foot

Definition: The cost per foot ($/foot) and per pair-foot of copper feeder cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself. The copper investment per pair-foot is used in estimating comparative life-cycle costs for copper feeder.

Default Values:

Copper Feeder Investment	
Cable Size	$/foot (u/g & aerial)
4200	$29.00
3600	$26.00
3000	$23.00
2400	$20.00
1800	$16.00
1200	$12.00
900	$10.00
600	$7.75
400	$6.00
200	$4.25
100	$2.50
Copper Investment per Pair - foot	
$ 0.0075 / pair-ft.	

Support: These costs reflect the use of 24-gauge copper feeder cable for cable sizes below 400 pairs, and 26-gauge copper feeder cable for cable sizes of 400 pairs and larger. Although 24-gauge copper is not required for transmission requirements within 18,000 feet of a digital central office with a 1,500 ohm limit, a heavier gauge of copper is used in smaller cable sizes to prevent damage from craft handling wires in pedestals where wires may be exposed, rather than sealed in splice cases. For cables of 400 pairs and larger, splices are normally enclosed in splice cases, and are not subject to wire handling problems.

Cable below 400 Pairs: Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of copper cable was typically ($0.50 + $0.01 per pair) per foot, current costs are typically ($0.30 + $0.007 per pair) per foot.

In the opinion of expert outside plant engineers, whose experience includes writing and administering hundreds of outside plant "estimate cases" (large undertakings), material represents approximately 40% of the total installed cost. This is a widely used rule of thumb among outside plant engineers. Such expert opinions were also used to determine that the average engineering content for installed copper cable is 15% of the installed cost. The remaining 45% represents direct labor for placing and splicing cable, exclusive of the cost of splicing block terminals into the cable.

Cable of 400 Pairs and Larger: As copper cable sizes become larger, engineering cost is based more and more on sheath feet, rather than cable size. The same is true for cable placing and splice set-up. Therefore the linear relationship between the number of copper pairs and installed cost is somewhat reduced. A

review of many installed cable costs around the country were used by the engineering team to estimate the installed cost of copper cable for sizes of 400 pairs and larger.

The following chart represents the default values used in the Model.

Copper Feeder Cable

Y-axis: Installed Investment ($0.00 to $30.00)
X-axis: Cable Size (0 to 4200)
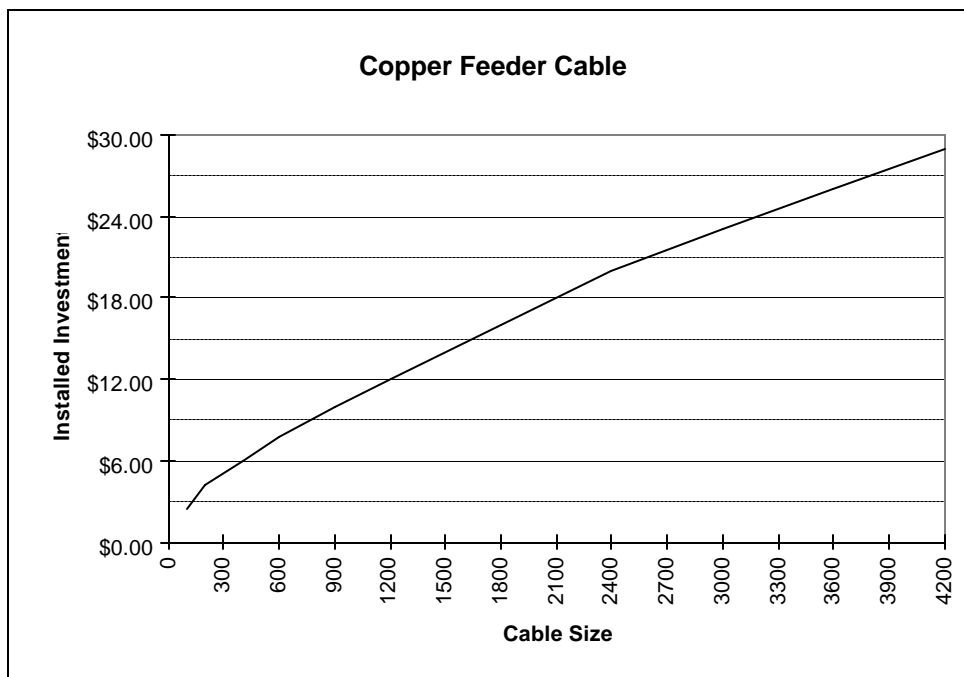
Copper Investment per Pair-Foot:
At the point in the model where a decision is required regarding copper vs. fiber feeder, it is not possible to determine how many copper pairs will be aggregated along each tapered section of the feeder route. Therefore a design assumption is required to determine how much of the fixed cost of the copper cable placement and sheath cost is distributed over the number of copper feeder pairs deployed. This is approximately $0.0075 per copper pair foot in the model.

3.4.2. Fiber Feeder Cable: Cost per Foot, Cost per Strand - Foot

Definition: The cost per foot ($/foot) and per strand-foot of fiber feeder cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself. The fiber investment per strand-foot is used in estimating comparative life-cycle costs for copper and fiber feeder.

Default Values:

Fiber Feeder Investment	
Cable Size	$/foot (u/g & aerial)
216	$13.10
144	$9.50
96	$7.10
72	$5.90
60	$5.30
48	$4.70
36	$4.10
24	$3.50
18	$3.20
12	$2.90
Fiber Investment per Strand - foot	
$ 0.10 / fiber-ft.	

Support: Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of fiber cable was typically ($0.50 + $0.10 per fiber) per foot, current costs are typically ($0.30 + $0.05 per fiber) per foot.

Splicing Engineering and Direct Labor are included in the cost of the Remote Terminal Installations, and the Central Office Installations, since field splicing is unnecessary with fiber cable pulls that are as long as 35,000 feet between splices.

Placing Engineering and Direct Labor are estimated at $2.00 per foot, consisting of $0.50 in engineering per foot, plus $1.50 direct labor per foot. These estimates were provided by a team of Outside Plant Engineering and Construction experts.

The following chart represents the default values used in the model.

Fiber Cable Installed Cost
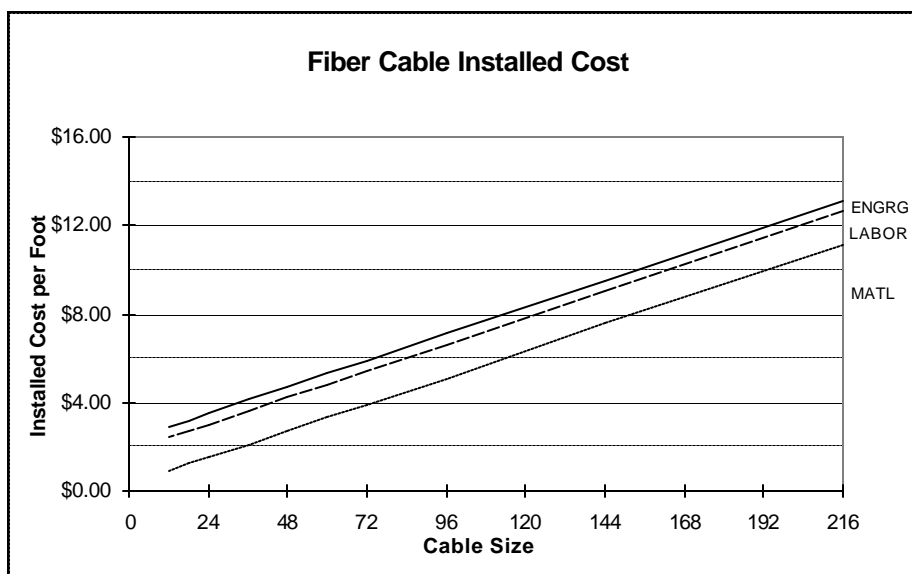
Fiber Investment per Strand – foot:

At the point in the model where a decision is required regarding copper vs. fiber feeder, it is not possible to determine how many fibers will be aggregated along each tapered section of the feeder route. Therefore a design assumption is required to determine how much of the fixed cost of the fiber cable placement and sheath cost is distributed over the number of fibers deployed. This is approximately $0.1000 per fiber strand foot in the model.

3.5. DLC EQUIPMENT

3.5.1. DLC Site and Power per Remote Terminal

Definition: The investment in site preparation and power for the remote terminal of a Digital Loop Carrier (DLC) system.

Default Values:

Remote Terminal Site and Power	
High Density GR-303 DLC	Low density GR-303 DLC
$3,000	$1,300

Support: The incremental per site cost was estimated by a team of outside plant experts with extensive experience in contracting for remote terminal site installations. Low Density DLC cabinets can be mounted on a small 41" x 38" prefabricated concrete or fiberglass pad.

3.5.2. Maximum Line Size per Remote Terminal

Definition: The maximum number of lines supported by the initial line module of a remote terminal.

Default Values:

Maximum Line Increment per Remote Terminal	
High Density GR-303 DLC	Low density GR-303 DLC
672	120

Support:

High Density Applications:
The forward looking DLC optimized for high density applications is an integrated NGDLC (Next Generation Digital Loop Carrier) compliant with Bellcore Generic Requirements GR-303, which employs an optical fiber SONET OC-3 transport capable of supporting 2016 full time DS0 POTS time slots. This is a large capacity and highly efficient digital loop carrier for serving the high density environment. While products from different vendors are available in a variety of sizes, HM 5.0a uses typical digital loop carrier remote sizes, which are as follows:

     672   DS0s   Modeled by HM 5.0a as an Initial Line Increment
  1344   DS0s   Modeled by HM 5.0a as an Initial Line Increment plus One Additional Increment
  2016   DS0s   Modeled by HM 5.0a as an Initial Line Increment plus Two Additional Increments

Low Density Applications:
       Similar to the high density environment, there are a wide variety of DLC products available for low density applications. These DLC products are NFDLC and are also GR-303 compliant. HM 5.0a uses a 50 Mbps fiber optic based NGDLC that can be configured in a variety of ways (Point-to-Point, Drop and Insert, and Tree Configurations), both as an Integrated Digital Loop Carrier and as a "stand-alone" or Universal Digital Loop Carrier. HM 5.0a utilizes the IDLC configuration. This is a highly efficient digital loop carrier for low density applications. While a variety of sizes are available, the following sizes are used in HM 5.0a:

     120   DS0s   Modeled by HM 5.0a as an Initial Line Increment
     240   DS0s   Modeled by HM 5.0a as an Initial Line Increment plus One Additional Increment

3.5.3. Remote Terminal Sizing Factor

Definition: The line unit sizing factor in a DLC remote terminal, that is, the ratio of lines served by a DLC remote terminal to the number of line units equipped in the remote terminal.

Default Values:

Remote Terminal Fill Factors	
High Density GR-303 DLC	Low Density GR-303 DLC
.90	.90

Support: The most expensive part of integrated digital loop carrier provisioning is the digital to analog conversion that takes place in the Remote Terminal line card. This expensive card (HM5.0a defaults to $310 per 4 line card) calls for stringent inventory control on the part of the ILEC. Also, fill factors are largely a function of the time frame needed to provide incremental additions. Since line cards are a highly portable asset, facility relief can be provided by dispatching a technician with line cards, rather than engaging in a several month long copper cable feeder addition. Therefore high fill rates should be the norm for an efficient provider using forward looking technology.

3.5.4. DLC Initial Common Equipment Investment

Definition: The installed cost of all common equipment and housing in the remote terminal, as well as the fiber optics multiplexer required at the CO end, for the initial line module of the DLC system (assumes integrated digital loop carrier (IDLC) with a GR-303 interface to the local digital switch).

Default Values:

Remote Terminal Initial Common Equipment Investment	
High Density GR-303 DLC	Low Density GR-303 DLC
$66,000	$16,000

Support: The cost of an initial increment of Integrated Digital Loop Electronics was estimated by a team of experienced outside plant experts with extensive experience in contracting for remote terminal site installations. Low Density DLC material investments are based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

3.5.5. DLC Channel Unit Investment

Definition: The investment in channel units required in the remote terminal of the DLC system.

Default Values:

GR-303 and low density DLC channel unit investment per unit				
	POTS Channel Unit		Coin Channel Unit	
DLC Type	Channel Card	No. Lines	Channel Card	No. Lines
High Density GR-303	$310	4	$250	2
Low Density GR-303	$600	6	$600	6

Support: The cost of individual POTS Channel Unit Cards was estimated by a team of experienced outside plant experts with extensive experience in contracting for DLC channel units. For the Low Density DLC, the cost is based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

3.5.6. DLC Lines per Channel Unit

Definition: The number of lines that can be supported on a single DLC channel unit.

Default Values:

Lines per Channel Unit		
	POTS Channel Unit	Coin Channel Unit
DLC Type	No. Lines	No. Lines
High Density GR-303	4	2
Low Density GR-303	6	6

Support: This is based on vendor documentation.

3.5.7. Low Density DLC to GR-303 DLC Cutover

Definition: The threshold number of lines served, above which the GR-303 DLC will be used.

Default Value:

Low Density GR-303 DLC to High Density GR-303 DLC Cutover
480 lines

Support: An analysis of initial costs reveals that 2 Low Density DLC units, at 240 lines each, are more cost effective than a single large IDLC unit with a capacity of 672 lines. Beyond two 240 line Low Density DLC units, the larger unit is less costly.

3.5.8. Fiber Strands per Remote Terminal

Definition: The number of fibers connected to each DLC remote terminal.

Default Values:

Fibers per Remote Terminal	
High Density GR-303 DLC	Low density GR-303 DLC
4	4

Support: HM 5.0a assumes a configuration with two main fibers (one for transmit and one for receive) and two protection fibers (one for transmit and one for receive). The protection fibers are equipped and provide transmission redundancy for improved service reliability. The number of fibers required is based on vendor documentation.

3.5.9. Optical Patch Panel

Definition: The investment required for each optical patch panel associated with a DLC remote terminal.

Default Values:

Optical Patch Panel	
High Density GR-303 DLC	Low density GR-303 DLC
$1,000	$1,000

Support: The cost for an installed fiber optic patch panel, including splicing of the fibers to pigtails, was estimated by a team of experienced outside plant experts with extensive experience in contracting for optical patch panels. A fiber optic patch panel contains no electronic, nor moving parts, but allows for the physical cross connection of fiber pigtails.

3.5.10. Copper Feeder Maximum Distance, Feet

Definition: The feeder length above which fiber feeder cable is used in lieu of copper cable. The value must be less than 18,000 feet.
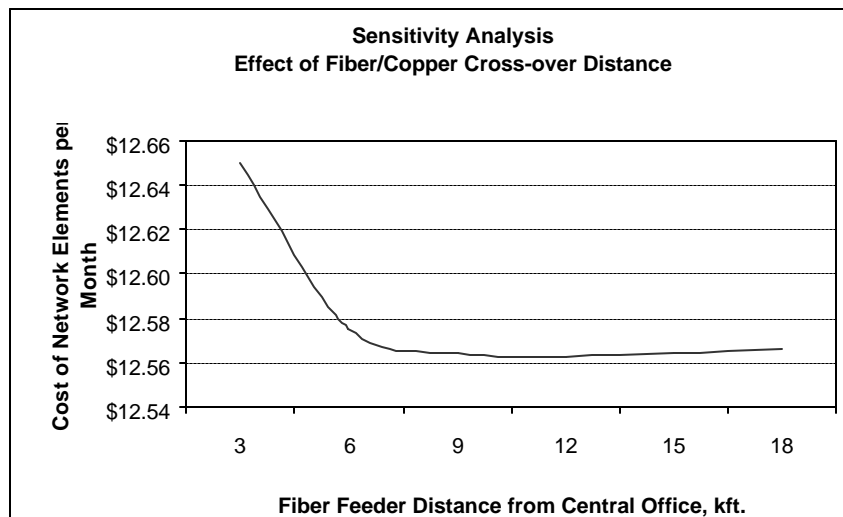
Default Value:

Copper Feeder Maximum Distance
9,000 feet

Support: The chart below depicts the result of multiple sensitivity runs of the HAI Model, wherein the only variable changed is the copper/fiber maximum distance point. Results indicate that Loop Costs per month drop off as the fiber/copper cross-over distance is increased. This reduction in monthly costs is a function of the investment and maintenance carrying charges for the loop. There is a significant slope from an all fiber feeder at 0 kft. down to 9,000 feet, where the slope becomes essentially flat.

HM 5.0a uses several parameters to determine the need for fiber feeder cable, rather than copper feeder cable. These include 1) assuring that the total copper cable length for both copper feeder and copper distribution do not exceed the threshold value set by default at 18,000 feet; 2)assuring that the copper distribution distance alone does not exceed the threshold value set by default at 18,000 feet; 3) assuring that copper feeder cable does not exceed the Copper Feeder Maximum Distance set by default here at 9,000 feet; and lastly, HM 5.0a tests to see if copper feeder is called for after examining the 3 tests above, whether

fiber feeder would have a lower life-cycle cost than copper feeder based on annual carrying charges that include the effects of differences for investment in copper cable vs. fiber cable plus IDLC, depreciation rate differences between technologies, and maintenance cost differences between technologies. If fiber based technology is less expensive, then HM 5.0a will re-compute the copper feeder as fiber feeder.

Sensitivity Analysis
Effect of Fiber/Copper Cross-over Distance

Cost of Network Elements per Month vs. **Fiber Feeder Distance from Central Office, kft.**

3.5.11. Common Equipment Investment per Additional Line Increment

Definition: The cost of the common equipment required for each additional line module in a remote terminal.

Default Values:

Common Equipment Investment per Additional Line Increment	
High Density GR-303 DLC	Low density GR-303 DLC
672 Line Increment	120 Line Increment
$18,500	$9,400

Support: The cost of an additional increment of Integrated Digital Loop Electronics was estimated by a team of experienced outside plant experts with extensive experience in contracting for remote terminal site installations. Low Density DLC material costs are based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

3.5.12. Maximum Number of Additional Line Modules per Remote Terminal

Definition: The number of line modules (in increments of 672 or 120 lines) that can be added to a remote terminal.

Default Values:

Max. # Add. Line Modules/RT	
High Density GR-303 DLC	Low density GR-303 DLC
2	1

Support: A standard OC-3 multiplexed site can provide 3 OC-1 systems, each at 672 lines. The HAI Model allows for adding 2 additional Common Equipment Investment modules to an initial 672 line system, and 1 additional Common Equipment Investment module to an initial 120 line system.

High Density Applications:

While products from different vendors of large NGDLC remotes for high density applications are available in a variety of sizes, HM 5.0a models typical digital loop carrier remote sizes as follows:

672 DS0s   Modeled by HM 5.0a as an Initial Line Increment
1344 DS0s   Modeled by HM 5.0a as an Initial Line Increment plus One Additional Increment
2016 DS0s[3]   Modeled by HM 5.0a as an Initial Line Increment plus Two Additional Increments

Low Density Applications:

Similarly, there are a wide variety of DLC products available for low density applications. The following sizes are modeled in HM 5.0a:

120 DS0s   Modeled by HM 5.0a as an Initial Line Increment
240 DS0s   Modeled by HM 5.0a as an Initial Line Increment plus One Additional Increment

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[3] *Note: 2016 line Remote Terminal Cabinets have been available in the market place for some time, and have been observed at field sites by our team of outside plant engineering experts who have taken photographs of sample sites.*

## 3.6. MANHOLE INVESTMENT – COPPER FEEDER

Definition: The installed cost of a prefabricated concrete manhole, including backfill and restoration. All the non-italicized costs in the following table are separately adjustable.

Default Values:

Copper Cable Manhole Investment						
Density Zone	Materials	Frame & Cover	Site Delivery	Total Material	Excavation & Backfill	Total Installed Manhole
0-5	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
5-100	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
100-200	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
200-650	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
650-850	$1,865	$350	$125	*$2,340*	$3,200	*$5,540*
850-2,550	$1,865	$350	$125	*$2,340*	$3,500	*$5,840*
2,550-5,000	$1,865	$350	$125	*$2,340*	$3,500	*$5,840*
5,000-10,000	$1,865	$350	$125	*$2,340*	$5,000	*$7,340*
10,000+	$1,865	$350	$125	*$2,340*	$5,000	*$7,340*

Support: Costs for various excavation methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries validated the opinions of outside plant experts and are revealed in the following charts.

Manhole Excavation & Backfill
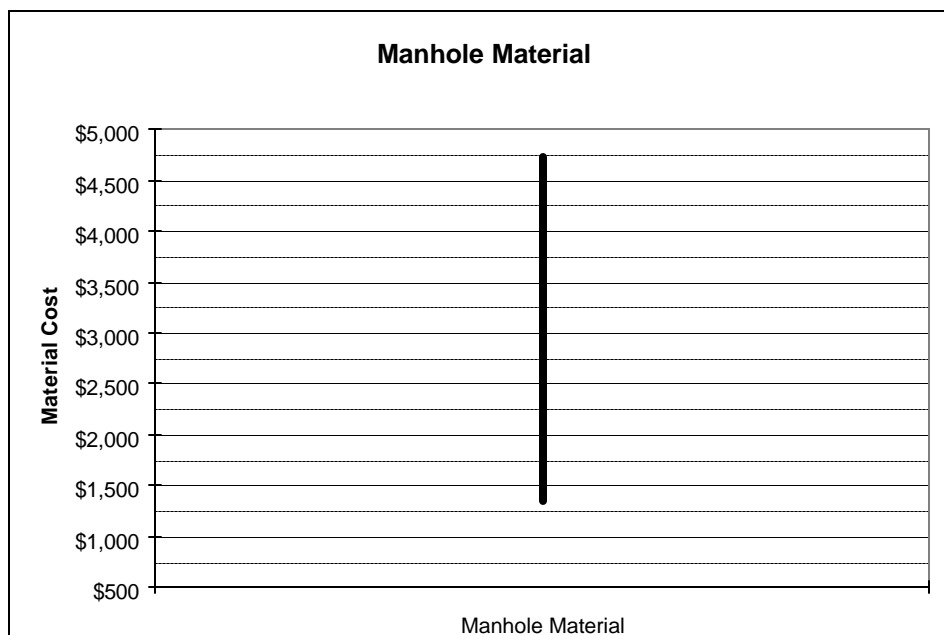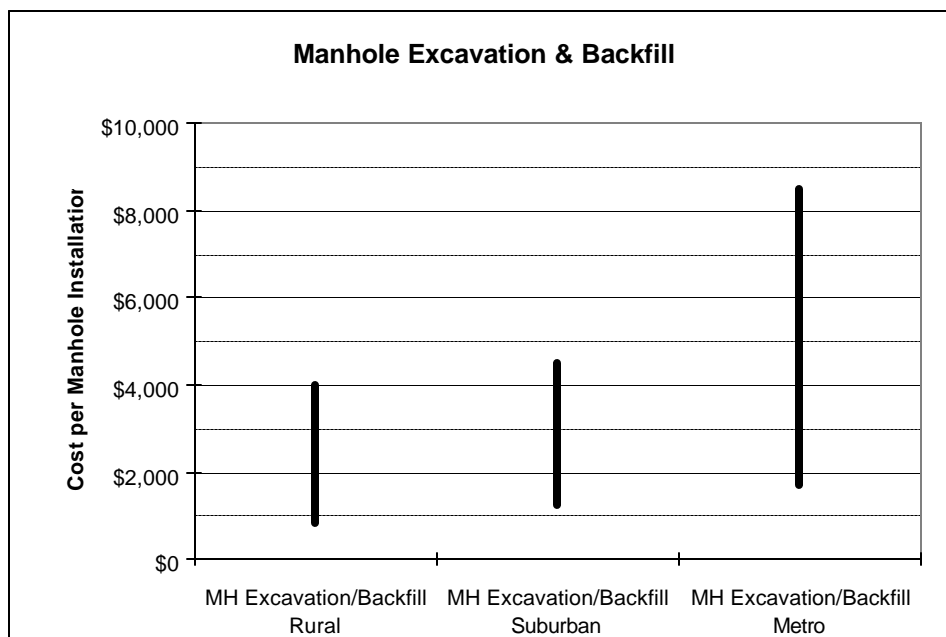
3.6.1. Dewatering Factor for Manhole Placement

Definition: The fractional increase in manhole placement to reflect additional cost required to install manholes in the presence of shallow water table. Default value is 0.2, indicating that high water tables will increase excavation and restoral cost by 20%.

Default Value:

Dewatering Factor Manhole Investment
0.20

Support: Ground water is not normally a problem with plowing and trenching; it softens the ground and usually does not hinder excavation work. In the rare cases of very wet conditions, contractors simply make sure they always use track vehicles, which is the normal type of equipment used in any case.

Manhole excavation and placement, however, can involve somewhat increased costs. In very high water table areas, a concrete manhole will actually tend to float while contractors attempt placement, requiring additional pumping and dewatering during construction work. After the manhole is in place, no additional cost is involved because of water.

3.6.2. Water Table Depth for Dewatering

Definition: Water table depth at which dewatering factor is invoked.

Default Value:

Water Table Depth for Dewatering, ft.
5.00 ft.

Support: Class A manholes are normally placed at a depth of approximately 8 feet. Some residual water is typical. Therefore, a default value of 5 feet is recommended to represent any additional cost incurred to care for high water difficulties in manhole placements.

3.7. PULLBOX INVESTMENT – FIBER FEEDER

Definition: The investment per fiber pullbox in the feeder portion of the network.

Default Values:

Fiber Pullbox Investment		
Density Zone	Pullbox Materials	Pullbox Installation
0-5	$280	$220
5-100	$280	$220
100-200	$280	$220
200-650	$280	$220
650-850	$280	$220
850-2,550	$280	$220
2,550-5,000	$280	$220
5,000-10,000	$280	$220
10,000+	$280	$220

Support: The information was received from a Vice President of PenCell Corporation at Supercom '96. He stated a price of approximately $280 for one of their larger boxes, without a large corporate purchase discount. Including installation, HM 5.0a uses a default value of $500.

4. SWITCHING AND INTEROFFICE TRANSMISSION PARAMETERS

4.1. END OFFICE SWITCHING

4.1.1. Switch Real-Time Limit, BHCA

Definition: The maximum number of busy hour call attempts (BHCA) a switch can handle. If the model determines that the load on a processor, calculated as the number of busy hour call attempts times the processor feature load multiplier, exceeds the switch real time limit multiplied by the switch maximum processor occupancy, it will add a switch to the wire center.

Default Values:

Switch Real-time limit, BHCA	
Lines Served	BHCA
1-1,000	10,000
1,000-10,000	50,000
10,000-40,000	200,000
40,000+	600,000

Support: Industry experience and expertise of HAI. These numbers are well within the range of the BHCA limitations NORTEL supplies in its Web site.[4]

Busy Hour Call Attempt Limits from Northern Telecom Internet Site	
Processor Series	BHCA
SuperNode Series 10	200,000
SuperNode Series 20	440,000
SuperNode Series 30	660,000
SuperNode Series 40	800,000
SuperNode Series 50 (RISC)	1,200,000
SuperNode Series 60 (RISC)	1,400,000 (burst mode)

4.1.2. Switch Traffic Limit, BHCCS

Definition: The maximum amount of traffic, measured in hundreds of call seconds (CCS), the switch can carry in the busy hour (BH). If the model determines that the offered traffic load on an end office switching network exceeds the traffic limit, it will add a switch.

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[4] See Northern Telecom's Web site at *http://www.nortel.com*

Default Values:

Lines	Busy Hour CCS
1-1,000	30,000
1,000-10,000	150,000
10,000-40,000	600,000
40,000+	1,800,000

Support: Values selected to be consistent with BHCA limit assuming an average holding time of five minutes.

4.1.3. Switch Maximum Equipped Line Size

Definition: The maximum number of lines plus trunk ports that a typical digital switching machine can support.

Default Value:

Switch Maximum Equipped Line Size
80,000

Support: This is a conservative assumption based on industry common knowledge and the Lucent Technologies web site.[5] The site states that the 5ESS-2000 can provide service for "up to as many as 100,000 lines but can be engineered even larger." The HAI Model lowers the 100,000 to 80,000, or 80 percent, recognizing that planners will not typically assume the full capacity of the switch can be used.

4.1.4. Switch Port Administrative Fill

Definition: The percent of lines in a switch that are assigned to subscribers compared to the total equipped lines in a switch.

Default Value:

Switch Port Administrative Fill
0.98

Support: Industry experience and expertise of HAI in conjunction with subject matter experts.

4.1.5. Switch Maximum Processor Occupancy

Definition: The fraction of total capacity (measured in busy hour call attempts, BHCA) an end office switch is allowed to carry before the model adds another switch.

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[5] See Lucent's Web site at *http://www.lucent.com/netsys/5ESS/5esswtch.html*

Default Value:

Switch Maximum Processor Occupancy
0.90

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989, figure 17.5-1, p. 17-24.

4.1.6. MDF/Protector Investment per Line

Definition: The Main Distribution Frame investment, including protector, required to terminate one line. According to Lucent's Web site, a main distribution frame is "a framework used to cross-connect outside plant cable pairs to central office switching equipment, but also carrier facility equipment such as Office Repeater Bays and SLC[R] Carrier Central Office Terminals. The MDF is usually used to provide protection and test access to the outside plant cable pairs."

Default Value:

MDF/Protector Investment per Line
$12.00

Support: This price was obtained by Telecom Visions, Inc., a consulting firm that assisted in the preparation of this Input Portfolio,, from a major manufacturer of MDF frames and protectors. A review of this price with information available in various proceedings indicates that this is a competitive investment cost.

4.1.7. Analog Line Circuit Offset for DLC Lines, per Line

Definition: The reduction in per line switch investment resulting from the fact that line cards are not required in both the switch and remote terminal for DLC-served lines.

Default Value:

Analog Line Circuit Offset for DLC Lines
$5.00 per line

Support: This is a HAI estimate, which is used in lieu of forward looking alternatives from public sources or ILECs. It is based on consultations with AT&T and MCI subject matter experts.

4.1.8. Switch Installation Multiplier

Definition: The telephone company investment in switch engineering and installation activities, expressed as a multiplier of the switch investment.

Default Value:

Switch Installation Multiplier
1.10

Support: The 10% factor used in the HAI model was derived based on the following information: Bell Atlantic ONA filing (FCC Docket 92-91) on February 13, 1992, showed a range of engineering factors for the different Bell Atlantic states between .08 and .108. The SBC ONA filing (FCC Docket 92-91) on May 18, 1992, showed a range of engineering and plant labor factors added together between .0879 and .1288. The 10% incremental-based factor is a fairly conservative estimate, given the ranges filed by two RBOCs using traditional ARMIS-based embedded cost factor development.

4.1.9. End Office Switching Investment Constant Term

Definition: The value of the constant ("B") appearing in the function that calculates the per line switching investment as a function of switch line size for an amalgam of host-remote and stand alone switches, expressed separately for BOCs and large independents (ICOs), on the one hand, and for small ICOs, on the other hand. The function is cost per line = A ln X + B, where X is the number of lines.

Default Values:

End Office Switching Investment Constant Term	
BOC & Large ICO	Small ICO
$242.73	$416.11

Support: The switching cost surveys were developed using typical per-line prices paid by BOCs, GTE and other independents as reported in the Northern Business Information (NBI) publication, "U.S., Central Office Equipment Market: 1995 Database," compared to switch size and data from the ARMIS 43-07 report.[6]

4.1.10. End Office Switching Investment Slope Term

Definition: The constant multiplying the log function appearing in the EO switching investment function ("A" in the function shown in parameter 4.1.9.) that calculates the per line switching investment as a function of switch line size for an amalgam of host-remote and stand alone switches. This term is the same for BOCs, large independents, and small independents.

Default Value:

EO Switching Investment Slope Term
-14.922

Support: The switching cost surveys were developed using typical per-line prices paid by BOCs, GTE and other independents as reported in the Northern Business Information (NBI) publication, "U.S., Central Office Equipment Market: 1995 Database," compared to switch size and data from the ARMIS 43-07 report.[7]

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[6] Northern Business Information study: *U.S. Central Office Equipment Market – 1995*, McGraw-Hill, New York, 1996.

4.1.11. Processor Feature Loading Multiplier

Definition: The amount by which the load on a processor exceeds the load associated with ordinary telephone calls, due to the presence of vertical features, Centrex, etc., expressed as a multiplier of nominal load.

Default Value: 1.20 for business line percentage up to the variable business penetration rate, increasing linearly above that rate to a final value of 2.00 for 100% business lines.

Support: This is a HAI estimate of the impact of switch features typically utilized by businesses on switch processor load. The assumption is that business lines typically invoke more features and services. Therefore, business lines affect processor real time loading more than residential lines. It is based on consultations with AT&T and MCI subject matter experts.

4.1.12. Business Penetration Ratio

Definition: The ratio of business lines to total switched lines at which the processor feature loading multiplier is assumed to reach the "heavy business" value of 2.

Default Value:

Business Penetration Ratio
0.30

Support: This is a HAI estimate of the point at which the number of business lines will cause the 20 percent processor load addition. It is based on consultations with AT&T and MCI subject matter experts.

4.2. WIRE CENTER

4.2.1. Lot Size, Multiplier of Switch Room Size

Definition: The multiplier of switch room size to arrive at total lot size to accommodate building and parking requirements.

Default Value:

Lot Size, Multiplier of Switch Room Size
2.0

Support: This is a HAI estimate.

4.2.2. Tandem/EO Wire Center Common Factor

Definition: The percentage of tandem switches that are also end office switches. This accounts for the fact that tandems and end offices are often located together, and is employed to avoid double counting of switch common equipment and wire center investment in these instances.

Default Value:

Tandem/EO Wire Center Common Factor
0.4

Support: This is a conservatively low estimate of the number of shared-use switches based on Bellcore's Local Exchange Routing Guide (LERG) data.

4.2.3. Power Investment

Definition: The wire center investment required for rectifiers, battery strings, back-up generators and various distributing frames, as a function of switch line size.

Default Values:

Lines	Investment Required
0	$5,000
1000	$10,000
5000	$20,000
25,000	$50,000
50,000	$250,000

Support: This is a HAI Estimate.

4.2.4. Switch Room Size

Definition: The area in square feet required housing a switch and its related equipment.

Default Values:

Switch Room Size	
Lines	Sq. Feet of Floor Space Required
0	500
1,000	1,000
5,000	2,000
25,000	5,000
50,000	10,000

Support: Industry experience and expertise of HAI along with information taken from manufacturer product literature (e.g., Nortel DMS-500 Planner and 5ESS Switch Information Guide). Furthermore, these values are supported by discussions over the years with personnel from LECs and competitive access providers who are familiar with the size of switch rooms through installing switches and/or acquiring space for network switches.

4.2.5. Construction Costs, per Square Foot

Definition: The costs of construction of a wire center building.
Default Values:

Construction Costs per sq. ft.	
Lines	Cost/sq. ft.
0	$75
1,000	$85
5,000	$100
25,000	$125
50,000	$150

Support: This is a HAI estimate. Although cost per square foot generally decreases as building size increases, the construction cost per square foot is assumed to increase with the number of lines served to account for higher prices typically associated with greater population densities where larger switches tend to be located.

4.2.6. Land Price, per Square Foot

Definition: The land price associated with a wire center.

Default Values:

Lines	Price/sq. ft.
0	$5.00
1,000	$7.50
5,000	$10.00
25,000	$15.00
50,000	$20.00

Support: This is a HAI estimate. Land cost per square foot are assumed to increase with the number of lines served to account for higher prices typically associated with greater population densities where larger switches are located.

4.3. TRAFFIC PARAMETERS

4.3.1. Local Call Attempts

Definition : The number of yearly local call attempts, as reported to the FCC.

Default Value: Taken from ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line local call attempt value for all ICOs reporting to ARMIS.

4.3.2. Call Completion Fraction

Definition: The percentage of call attempts that result in a completed call. Calls that result in a busy signal, no answer, or network blockage are all considered incomplete.

Default Value:

Call Completion Fraction
0.7

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989. This number is a composite of the results shown in table 17.6-B.

4.3.3. IntraLATA Calls Completed

Definition : The number of yearly intraLATA completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line IntraLATA calls completed value for all ICOs reporting to ARMIS.

4.3.4. InterLATA Intrastate Calls Completed

Definition : The number of yearly interLATA intrastate completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line interLATA intrastate calls completed value for all ICOs reporting to ARMIS.

4.3.5. InterLATA Interstate Calls Completed

Definition : The number of yearly interLATA interstate completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line interLATA interstate calls completed value for all ICOs reporting to ARMIS.

4.3.6. Local DEMs, Thousands

Definition : The number of yearly local Dial Equipment Minutes (DEMs), as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.15.

4.3.7. Intrastate DEMs, Thousands

Definition: The number of yearly intrastate DEMs, as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.16.

4.3.8. Interstate DEMs, Thousands

Definition: The number of yearly interstate DEMs, as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.17.

4.3.9. Local Business/Residential DEMs Ratio

Definition: The ratio of local Business DEMs per line to local Residential DEMs per line

Default Value:

Local Bus / Res DEMs Ratio
1.1

Support: This is a HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.10. Intrastate Business/Residential DEMs

Definition: The ratio of intrastate Business DEMs per line to intrastate Residential DEMs per line

Default Value:

Intrastate Bus / Res DEMs Ratio
2

Support: This is a HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.11. Interstate Business/Residential DEMs

Definition: The ratio of interstate Business DEMs per line to interstate Residential DEMs per line

Default Value:

Interstate Bus / Res DEMs Ratio
3

Support: This is a HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.12. Busy Hour Fraction of Daily Usage

Definition: The percentage of daily usage that occurs during the busy hour.

Default Value:

Busy Hour Fraction of Daily Usage
0.10

Support: AT&T Capacity Cost Study.[8]

4.3.13. Annual to Daily Usage Reduction Factor

Definition: The effective number of business days in a year, used to concentrate annual usage into a fewer number of days as a step in determining busy hour usage.

Default Value:

Annual to Daily Usage Reduction Factor
270

Support: The AT&T Capacity Cost Study uses an annual to daily usage reduction factor of 264 days.[9]

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[8] Blake, V.A., Flynn, P.V., Jennings, F.B., AT&T Bell Laboratories, *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth",* June 20, 1990, p.10. Filed in CC Docket No. 90-132.

[9] Blake, V.A., Flynn, P.V., Jennings, F.B., AT&T Bell Laboratories, *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth",* June 20, 1990, p.10. Filed in CC Docket No. 90-132.

4.3.14. Holding Time Multipliers, Residential/Business

Definition: The potential modification to the average call "holding time" (i.e., duration) to reflect Internet use or other causes, expressed as a multiplier of the holding time associated with ordinary residential or business telephone calls.

Default Values:

Holding time multipliers	
Residential	Business
1.0	1.0

Support: The purpose of this parameter is to allow users to study the impact of increasing the offered load on the network. The default value of 1 means the load is that estimated from DEMs.

4.3.15. Call Attempts, Busy Hour (BHCA), Residential/Business

Definition: The number of call attempts originated per residential and business subscriber during the busy hour.

Default Values:

Busy Hour Call Attempts	
Residential	Business
1.3	3.5

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989. This number is a composite of the results shown in table 17.6 C-G.

4.4. INTEROFFICE INVESTMENT

4.4.1. Transmission Terminal Investment

Definition: The investment in 1) the fully-equipped add-drop multiplexer (ADM) that extracts/inserts signals into OC-48 or OC-3 fiber rings, and are needed in each wire center to connect the wire center to the interoffice fiber ring; and 2) the fully-equipped OC-3/DS-1 terminal multiplexers required to interface to the OC-48 ADM and to provide point to point circuits between on-ring wire centers and end offices not connected directly to a fiber ring. The "Investment per 7 DS-1" figure is the amount by which the investment in OC-3s is reduced for each unit of 7 DS-1s below full capacity of the OC-3. See the figure in Appendix A.

Default Values:

Transmission Terminal Investment			
OC-48 ADM, Installed		OC-3/DS-1 ADM/Terminal Multiplexer, Installed	Investment per 7 DS-1s
48 DS-3s	12 DS-3s	84 DS-1s	7 DS-1s
$50,000	$40,000	$26,000	$500

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.2. Number of Fibers

Definition: The assumed fiber cross-section, or number of fibers in a cable, in an interoffice fiber ring and point to point connection.

Default Value:

Number of Fibers
24

Support: The default value is consistent with common practices within the telecommunications industry and reflects the engineering judgment of HAI Model developers.

4.4.3. Pigtail Investment

Definition: The cost of the short fiber connectors that attach the interoffice ring fibers to the wire center transmission equipment via a patch panel.

Default Value:

Pigtail Investment
$60 each

Support: A public source estimates the cost of pigtails at $75.00 per fiber. See, Reed, David P., *Residential Fiber Optic Networks and Engineering and Economic Analysis*, Artech House, Inc., 1992, p.93. The lower amount reflects an HAI estimate of price trends since that figure was published.

4.4.4 Optical Distribution Panel

Definition: The cost of the physical fiber patch panel used to connect 24 fibers to the transmission equipment.

Default Value:

Optical Distribution Panel
$1,000

Support: The cost for an installed fiber optic patch panel, including splicing of the fibers to pigtails, was estimated by a team of experienced outside plant experts who have contracted for such installations. A fiber optic patch panel contains no electronic or moving parts, but allows for the physical cross connection of fiber pigtails.

4.4.5. EF&I, per Hour

Definition: The per-hour cost for the "engineered, furnished, and installed" activities for equipment in each wire center associated with the interoffice fiber ring, such as the "pigtails" and patch panels to which the transmission equipment is connected.

Default Value:

EF&I
$55 per hour

Support: This is a fully loaded labor rate used for the most sophisticated technicians. It includes basic wages and benefits, Social Security, Relief & Pensions, management supervision, overtime, exempt material and motor vehicle loadings. A team of experienced outside plant experts estimated this value.

4.4.6. EF&I, Units

Definition: The number of hours required to install the equipment associated with the interoffice transmission system (see EF&I, per hour, above) in a wire center.

Default Value:

EF&I, units
32 hours

Support: This amount of labor was estimated by a team of experienced engineering exp erts. It includes the labor hours to install and test the transport equipment involved in interoffice facilities.

4.4.7. Regenerator Investment, Installed

Definition: The installed cost of an OC-48 optical regenerator.

Default Value:

Regenerator Investment, Installed
$15,000

Support: This approximation was obtained from a representative of a major fiber optic multiplexer manufacturer at Supercom '96, in June 1996 in Dallas, Texas.

4.4.8. Regenerator Spacing, Miles

Definition: The distance between digital signal regenerators in the interoffice fiber optics transmission system.

Default Value:

Regenerator Spacing
40 miles

Support: Based on field experience of maximum distance before fiber regeneration is necessary. This number is conservatively low compared to Fujitsu product literature, which indicates a maximum regenerator spacing of 110km, or approximately 69 miles[10] (with post- and pre-amp).

4.4.9. Channel Bank Investment, per 24 Lines

Definition: The investment in voice grade to DS-1 multiplexers in wire centers required for some special access circuits.

Default Value:

Channel Bank Investment, per 24 lines
$5,000

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[10] Futjitsu Network Communications, Inc. product sheet for Flash™-192 multiplexer, *"Typical Optical Span Lengths SMF Fiber {Single Mode Fiber} 110 km (with post- and pre-amp)."*

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.10. Fraction of SA Lines Requiring Multiplexing

Definition: The percentage of special access circuits that require voice grade to DS-1 multiplexing in the wire center in order to be carried on the interoffice transmission system. This parameter is for use in conjunction with a study of the cost of special access circuits.

Default Value:

Fraction of SA Lines Requiring Multiplexing
0.0

Support: The default value of zero is appropriate for the existing set of UNEs, which do not include a special access UNE.

4.4.11. Digital Cross Connect System, Installed, per DS-3

Definition: The investment required for a digital cross connect system that interfaces DS-1 signals between switches and OC-3 multiplexers, expressed on a per DS-3 (672 DS-0) basis.

Default Value:

Digital Cross Connect System, Installed, per DS-3
$30,000

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.12. Transmission Terminal Fill (DS-0 level)

Definition: The fraction of maximum DS-0 circuit capacity that can actually be utilized in ADMs, DS-1 to OC-3 multiplexers, and channel banks.

Default Value:

Transmission Terminal Fill (DS-0 level)
0.90

Support: Based on outside plant subject matter expert judgment.

4.4.13. Interoffice Fiber Cable Investment per Foot, Installed

Definition: The installed cost per foot of interoffice fiber cable, assuming a 24-fiber cable.

Default Value:

Interoffice Fiber Cable Investment, Installed, per foot
$3.50

Support: *{NOTE: The discussion in Section 3.4.2. [Fiber Feeder] is reproduced here for ease of use.}*

Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of fiber cable was typically ($.50 + $.10 per fiber) per foot, current costs are typically ($.30 + $.05 per fiber) per foot.

Splicing Engineering and Direct Labor are included in the cost of the Remote Terminal Installations, and the Central Office Installations, since field splicing is unnecessary with fiber cable pulls as long as 35,000 feet between splices.

Placing Engineering and Direct Labor are estimated at $2.00 per foot, consisting of $0.50 in engineering per foot, plus $1.50 direct labor per foot. These estimates were provided by a team of Outside Plant Engineering and Construction experts.

The following chart represents the default values used in the model.

4.4.14. Number of Strands per ADM

Definition: The number of interoffice fiber strands connected to the ADM in each wire center. At least four strands per ADM are required around the ring.

Default Value:

Number of Strands per ADM
4

Support: This is the standard number of strands required by an ADM. It provides for redundant transmission in both directions around the interoffice fiber ring.

4.4.15. Interoffice Structure Percentages

Definition: The relative amounts of different structure types supporting interoffice transmission facilities. Aerial cable is attached to telephone poles or buildings, buried cable is laid directly in the earth, and underground cable runs through underground conduit. Aerial and buried percentages are entered by the user; the underground fraction is then computed.

Default Values:

Structure Percentages		
Aerial	Buried	Underground
20%	60%	*20%*

Support: These are average figures that reflect the judgment of a team of outside plant experts regarding the appropriate mix of density zones applicable to interoffice transmission facilities.

4.4.16. Transport Placement

Definition: The cost of fiber cable structures used in the interoffice transmission system.

Default Values:

Transport Placement, per foot	
Buried	Conduit
$1.77	$16.40

Support: Structures closer to the central office are normally shared with feeder cable. Additional structures at the end of feeder routes may be required to complete an interoffice transport path. Since distances farther from the central office normally involve lower density zones, average structure costs appropriate for lower density zones are reflected in the default values. A default value for Buried representing the lower density zones is used, while a conservatively higher value is used for Conduit, representing the default value expected in a 850-2,550 line per square mile density zone.

4.4.17. Buried Sheath Addition

Definition: The cost of dual sheathing for additional mechanical protection of fiber interoffice transport cable.

Default Value:

Buried Sheath Addition
$0.20 per foot

Support: *{NOTE: The discussion in Section 3.2.3. [Fiber Feeder] is reproduced here for ease of use.}*

Incremental cost for mechanical sheath protection on fiber optic cable is a constant per foot, rather than the ratio factor used for copper cable, because fiber sheath is approximately ½ inch in diameter, regardless of the number of fiber strands contained in the sheath. The incremental per foot cost was estimated by a team of experienced outside plant experts who have purchased millions of feet of fiber optic cable.

4.4.18. Interoffice Conduit, Cost and Number of Tubes

Definition: The cost per foot for interoffice fiber cable conduit, and the number of spare tubes (conduit) placed per route.

Default Values:

Interoffice Conduit, Cost and Number of Tubes	
Cost	Spare Tubes per Route
$0.60 per foot	1

Support: *{NOTE: The discussions in Sections 2.4.3. and 2.4.4. [Distribution] are reproduced here for ease of use.}*

Conduit Cost per foot:
Several suppliers were contacted for material prices. Results are shown below.
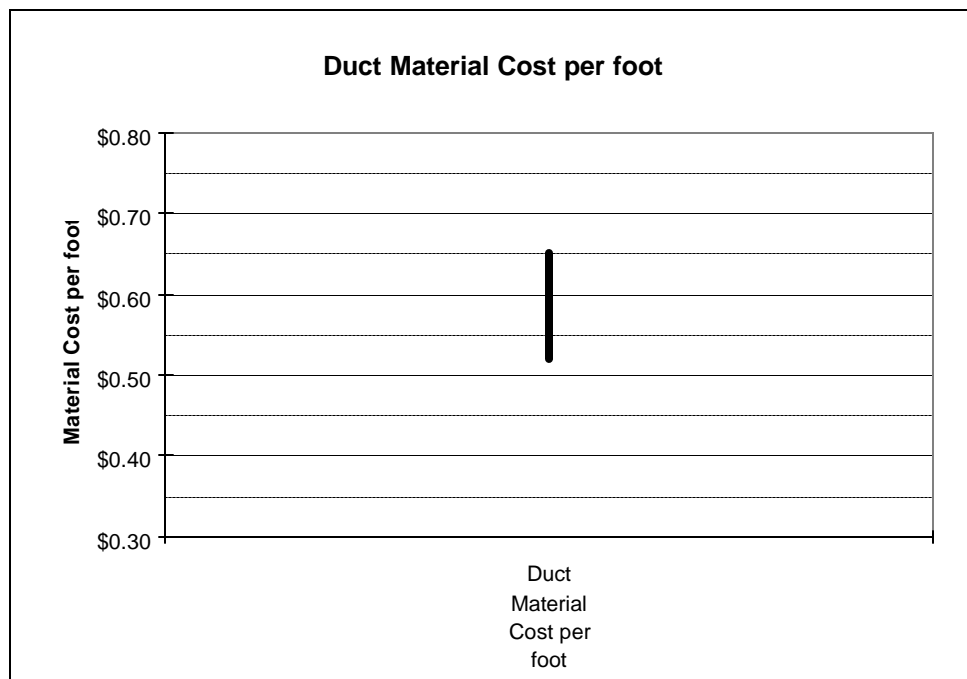
The labor to place conduit in trenches is included in the cost of the trench, not in the conduit cost.

Under the Model's assumptions, a relatively few copper cables serving short distances (e.g., less than 9,000 ft. feeder cable length), and one or more fiber cables to serve longer distances, will be needed. Since the number of cables in each of the four feeder routes is relatively small, the predominant cost is that of the trench, plus the material cost of a few additional 4" PVC conduit pipes. No additional allowance is necessary for stabilizing the conduit in the trench.

Spare Tubes per Route:
"A major advantage of using conduits is the ability to reuse cable spaces without costly excavation by removing smaller, older cables and replacing them with larger cables or fiber facilities. Some companies reserve vacant ducts for maintenance purposes."[11] Version 5.0a of the HAI Model provides one spare maintenance duct (as default) in each conduit run. In addition, if there is also a fiber feeder cable along with a copper feeder cable in the run, an additional maintenance duct (as a default) is provided in each conduit run to facilitate a fiber cable replacement at the same time a copper cable replacement may be required.

4.4.19. Pullbox Spacing

Definition: Spacing between pullboxes in the interoffice portion of the network.

Default Value:

Pullbox Spacing
2,000 feet

Support: *{NOTE: The discussion in Section 3.2.2. [Feeder] is reproduced here for ease of use.}*

Unlike copper manhole spacing, the spacing for fiber pullboxes is based on the practice of coiling spare fiber (slack) within pullboxes to facilitate repair in the event the cable is cut or otherwise impacted. Fiber feeder pullbox spacing is not a function of the cable reel lengths, but rather a function of length of cable placed. The standard practice during the cable placement process is to provide for 5 percent excess cable to facilitate subsurface relocation, lessen potential damage from impact on cable, or provide for ease of cable splicing when cable is cut or damaged.[12] It is common practice for outside plant engineers to require approximately 2 slack boxes per mile.

4.4.20. Pullbox Investment

Definition: Investment per fiber pullbox in the interoffice portion of the network.

Default Value:

Pullbox Investment
$500

Support: *{NOTE: The discussion in Section 3.7. [Fiber Feeder] is reproduced here for ease of use.}*

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[11] Bellcore, *BOC Notes on the LEC Networks - 1994*, p. 12-42.

[12] CommScope, *Cable Construction Manual, 4th Edition*, p. 75.

The information was received verbally from a Vice President of PenCell Corporation at their Supercom '96 booth. He stated a price of approximately $280 for one of their larger boxes, without a large corporate purchase discount. Including installation, HM 5.0a uses a default value of $500.

4.4.21. Pole Spacing, Interoffice

Definition: Spacing between poles supporting aerial interoffice fiber cable.

Default Value:

Pole Spacing, Interoffice
150 feet

Support: This is a representative figure accounting for the mix of density zones applicable to interoffice transmission facilities.

4.4.22. Interoffice Pole Material and Labor

Definition: The installed cost of a 40' Class 4 treated southern pine pole.

Default Values:

Pole Investment	
Materials	$201
Labor	<u>$216</u>
Total	*$417*

Support: {NOTE: The discussion in Section 2.4.1. [Distribution] is reproduced here for ease of use. Refer to Section 2.4.1. [Distribution] for material, labor and total pole investment as depicted in a compilation of pole data charts that has recently been filed by large telephone companies with the FCC.}

Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.
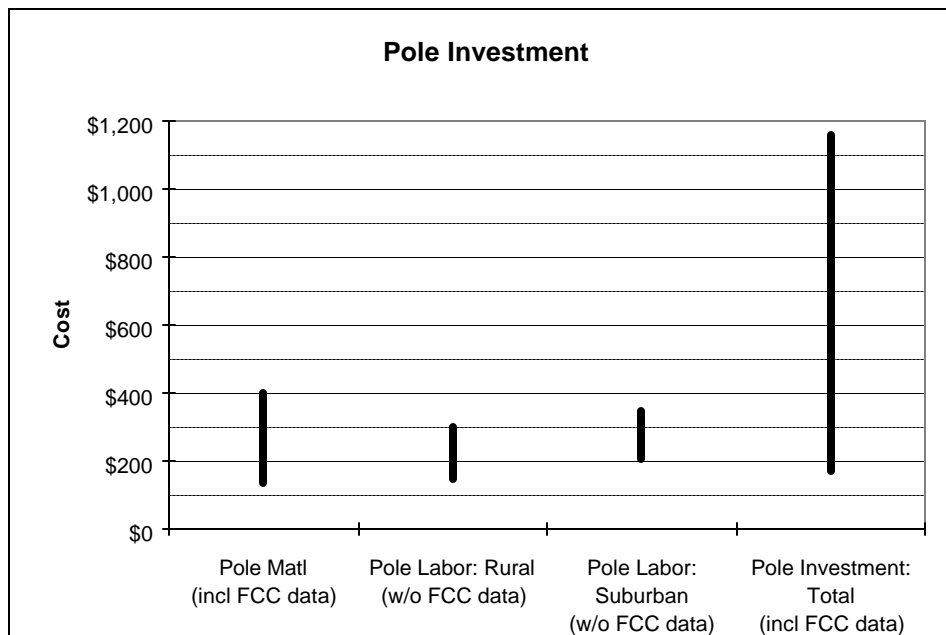
The exempt material load on direct labor includes ancillary material not considered by FCC Part 32 as a unit of plant. That includes items such as downguys and anchors that are already included in the pole placement labor cost. The steel strand run between poles is likewise an exempt material item, charged to the aerial cable account. The cost of steel strands is not included in the cost of poles; it is included in the installed cost of aerial cable.

4.4.23. Fraction of Interoffice Structure Common with Feeder

Definition: The percentage of structure supporting interoffice transport facilities that is also shared by feeder facilities, expressed as a fraction of the smaller of the interoffice and feeder investment for each of the three types of facilities (i.e., aerial, buried and underground are treated separately in calculating the amount of sharing).

Default Value:

Fraction of Interoffice Structure Common with Feeder
.75

Support: Interoffice transport facilities will almost always follow feeder routes which radiate from each central office. Typically only a small distance between adjacent wire centers is not traversed by a feeder route; for this distance, structure is appropriately assigned exclusively to interoffice transport. In the opinion of a team of outside plant engineers, the additional structure required exclusively for interoffice transport is no more than 25 percent of the distance. Therefore, 75 percent of the interoffice route is assumed by the HM 5.0a to be shared with feeder cables.

4.4.24. Interoffice Structure Sharing Fraction

Definition: The fraction of investment in interoffice poles and trenching that is assigned to LECs. The remainder is attributed to other utilities/carriers.

Default Values:

Fraction of Interoffice Structure Assigned to Telephone		
Aerial	Buried	Underground
.33	.33	.33

Support: The structure sharing with other utilities covered by this parameter involves the portion of interoffice structure that is not shared with feeder cable. Sharing with other utilities is assumed to include at least two other occupants of the structure. Candidates for sharing include electrical power, CATV, competitive long distance carriers, competitive local access providers, municipal services and others. See also Appendix B.

4.5. TRANSMISSION PARAMETERS

4.5.1. Operator Traffic Fraction

Definition: Fraction of traffic that requires operator assistance. This assistance can be automated or manual (see Operator Intervention Fraction in the Operator Systems section below)

Default Value:

Operator Traffic Fraction
0.02

Support: Industry experience and expertise of HAI.

4.5.2. Total Interoffice Traffic Fraction

Definition: The fraction of all calls that are completed on a switch other than the originating switch, as opposed to calls completed within a single switch.

Default Value:

Total Interoffice Traffic Fraction
0.65

Support: According to *Engineering and Operations in the Bell System*, Table 4-5, p. 125, the most recent information source found to date, the percentage of calls that are interoffice calls ranges from 34 percent for rural areas to 69 percent for urban areas. Assuming weightings according to the typical number of lines per wire center for each environment (urban, suburban, rural), these figures suggest an overall interoffice traffic fraction of approximately 65 percent.

4.5.3. Maximum Trunk Occupancy, CCS

Definition: The maximum utilization of a trunk during the busy hour.

Default Value:

Maximum Trunk Occupancy, CCS
27.5

Support: AT&T Capacity Cost Study.[13]

4.5.4. Trunk Port Investment, per End

Definition: Per-trunk equivalent investment in switch trunk port at each end of a trunk.

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[13] Blake, et al., *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p.4.

Default Value:

Trunk Investment, per end
$100

Support: AT&T Capacity Cost Study.[14] HAI judgment is that $100 is for the switch port itself.

4.5.5. Direct-Routed Fraction of Local Interoffice Traffic

Definition: The amount of local interoffice traffic that is directly routed between originating and terminating end offices as opposed to being routed via a tandem switch.

Default Value:

Direct-Routed Fraction of Local Interoffice
0.98

Support: The direct routed fraction of local interoffice is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.6. Tandem-Routed Fraction of Total IntraLATA Toll Traffic

Definition: Fraction of intraLATA toll calls that are routed through a tandem.

Default Value:

Tandem-Routed Fraction of Total IntraLATA Toll Traffic
0.2

Support: The tandem routed fraction of total intraLATA toll traffic is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.7. Tandem-Routed Fraction of Total InterLATA Traffic

Definition: Fraction of interLATA (IXC access) calls that are routed through a tandem instead of directly to the IXC.

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[14] Blake, et al., *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth,"*, p. 7.

Default Value:

Tandem-Routed Fraction of Total InterLATA Traffic
0.2

Support: The tandem routed fraction of total interLATA traffic is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.8. POPs per Tandem Location

Definition: The number of IXC points of presence requiring an entrance facility, per LEC tandem.

Default Value:

POPs per Tandem Location
5

Support: An assumption that envisions POPs for three principal IXCs plus two smaller carriers associated with each LEC tandem.

4.5.9. Threshold Value for Off-Ring Wire Centers

Definition: The threshold value, in lines, that determines whether a wire center should be included in ring calculations and therefore be a candidate to appear on (that is, be directly connected to) a ring. Wire centers whose size falls below the threshold will not be appear on a ring, but will be connected via a point-point link to the tandem switch or via a "spur" to the nearest wire center that is on a ring. Transmission equipment in such cases consists of terminal multiplexers and not ADMs. This parameter only applies to companies that own and operate a local tandem switch.

Default Value:

Threshold Value for Off-Ring Wire Centers, total lines
1

Support: The algorithm that calculates ring configurations includes a test to ensure it is economic to incur the cost of terminal equipment required to be on the ring. Therefore, no other arbitrary limitation is required.

4.5.10. Remote-Host Fraction of Interoffice Traffic

Definition: Fraction of local direct traffic assumed to flow from a remote to its host switch.

Default Value:

Remote – Host Fraction of Interoffice Traffic, Remote
0.10

Support: Based on HAI judgment.

4.5.11. Host-Remote Fraction of Interoffice Traffic

Definition: Fraction of local direct traffic assumed to flow from a host to its remotes.

Default Value:

Host – Remote Fraction of Interoffice Traffic, Host
0.05

Support: Based on HAI judgment.

4.5.12. Maximum Nodes per Ring

Definition: Maximum number of ADMs that are permitted on a single ring.

Default Value:

Maximum Nodes per Ring
16

Support: Buffering and other internal delays in add/drop mu ltiplexers (ADMs) ultimately limit the number of ADMs that can constitute a SONET ring. A 16-node limit is a typical value.[15]

4.5.13. Ring Transiting Traffic Factor

Definition: An estimated factor, representing the fraction of traffic that flows from one ring to another by way of a third, or "transit," ring.

Default Value:

Ring Transiting Traffic Factor
0.40

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[15] Fujitsu, *Network Design Features, FJTU-320-560-100, Issue 3, Revision 1*, December 1995, p.11.

Support: Based on HAI judgement of the amount of traffic between wire centers on different rings versus total interoffice traffic and the number of rings that must be transited between the originating and terminating wire center.

4.5.14. Intertandem Fraction of Tandem Trunks

Definition: A factor used to estimate the number of additional tandem trunks required to carry intertandem traffic.

Default Value:

Intertandem Fraction of Tandem trunks
0.10

Support: Based on HAI judgement.

4.6. TANDEM SWITCHING

4.6.1. Real Time Limit, BHCA

Definition: The maximum number of BHCA a tandem switch can process.

Default Value:

Real Time Limit, BHCA
750,000

Support: Industry experience and expertise of HAI. These numbers are well within the range of the BHCA limitations NORTEL supplies in its Web site. See 4.1.1.

4.6.2. Port Limit, Trunks

Definition: The maximum number of trunks that can be terminated on a tandem switch.

Default Value:

Port Limit, Trunks
100,000

Support: AT&T Updated Capacity Cost Study.[16]

4.6.3. Tandem Common Equipment Investment

Definition: The amount of investment in common equipment for a large tandem switch. Common Equipment is the hardware and software that is present in the tandem in addition to the trunk terminations themselves. The cost of a tandem is estimated by the HM as the cost of common equipment plus an investment per trunk terminated on the tandem.

Default Value:

Tandem Common Equipment Investment
$1,000,000

Support: AT&T Capacity Cost Study.[17]

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[16] Brand, T.L., Hallas, G.A., et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, April 19, 1995, p. 9.

[17] Blake, et. al., *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p.9.

4.6.4. Maximum Trunk Fill (Port Occupancy)

Definition: The fraction of the maximum number of trunk ports on a tandem switch that can be utilized.

Default Value:

Maximum Trunk Fill (port occupancy)
0.90

Support: This is a HAI estimate, which is used in lieu of forward looking alternatives from public sources or ILECs. It is based on consultations with AT&T and MCI subject matter experts.

4.6.5. Maximum Tandem Real Time Occupancy

Definition: The fraction of the total capacity (expresses as the real time limit, BHCA) a tandem switch is allowed to carry before an additional switch is provided.

Default Value:

Maximum Tandem Real Time Occupancy
0.9

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989, figure 17.5-1, p. 17-24.

4.6.6. Tandem Common Equipment Intercept Factor

Definition: The multiplier of the common equipment investment input that gives the common equipment cost for the smallest tandem switch, allowing scaling of tandem switching investment according to trunk requirements.

Default Value:

Tandem Common Equipment Intercept Factor
0.50

Support: Value selected to allow tandem common equipment investment to range from $500,000 to $1,000,000 which is the appropriate range based on expertise of HAI.

4.6.7. Entrance Facility Distance from Serving Wire Center & IXC POP

Definition: Average length of trunks connecting an IXC POP with the wire center that serves it.

Default Value:

Entrance Facility Distance from Serving Wire Center & IXC POP
0.5 miles

Support: Value selected in recognition of the fact that IXCs typically locate POPs close to the serving wire center to avoid long cable runs.

4.7. SIGNALING

4.7.1. STP Link Capacity

Definition: The maximum number of signaling links that can be terminated on a given STP pair.

Default Value:

STP Link Capacity
720

Support: AT&T Updated Capacity Cost Study.[18]

4.7.2. STP Maximum Fill

Definition: The fraction of maximum links (as stated by the STP link capacity input) that the model assumes can be utilized before it adds another STP pair.

Default Value:

STP Maximum Fill
0.80

Support: The STP maximum fill factor is based on HAI engineering judgment and is consistent with maximum link/port fill levels throughout HM 5.0a.

4.7.3. STP Maximum Common Equipment Investment, per Pair

Definition: The cost to purchase and install a pair of maximum-sized STPs.

Default Value:

STP Maximum Common Equipment Investment, per pair
$5,000,000

Support: AT&T Updated Capacity Cost Study.[19]

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[18] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 26.

[19] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 26.

4.7.4. STP Minimum Common Equipment Investment, per Pair

Definition: The minimum investment for a minimum-capacity STP, i.e.: the fixed investment for an STP pair that serves a minimum number of links.

Default Value:

STP Minimum Common Equipment Investment, per pair
$1,000,000

Support: It is necessary to allow the scaling of STP common equipment for smaller STPs that in some configuration are sufficient for local exchange carriers. The minimum STP common equipment investment cost is an HAI judgment of the lower end of the range of common equipment investment.

4.7.5. Link Termination, Both Ends

Definition: The investment required for the transmission equipment that terminates both ends of an SS7 signaling link.

Default Value:

Link Termination, Both Ends
$900

Support: AT&T Updated Capacity Cost Study.[20]

4.7.6. Signaling Link Bit Rate

Definition: The rate at which bits are transmitted over an SS7 signaling link.

Default Value:

Signaling Link Bit Rate
56,000 bits per second

Support: The AT&T Updated Capacity Cost Study, and an SS7 network industry standard.[21]

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[20] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 26.

[21] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 25.

4.7.7. Link Occupancy

Definition: The fraction of the maximum bit rate that can be sustained on an SS7 signaling link.

Default Value:

Link Occupancy
0.40

Support: AT&T Updated Capacity Cost Study .[22]

4.7.8. C Link Cross-Section

Definition: The number of C-links in each segment connecting a mated STP pair.

Default Value:

C Link Cross-Section
24

Support: The input was derived assuming the 56 kbps signaling links between STPs are normally transported in a DS-1 signal, whose capacity is 24 DS-0s.

4.7.9. ISUP Messages per Interoffice BHCA

Definition: The number of Integrated Services Digital Network User Part (ISUP) messages associated with each interoffice telephone call attempt. Switches send to each other ISUP messages over the SS7 network to negotiate the establishment of a telephone connection.

Default Value:

ISUP messages per interoffice BHCA
6

Support: AT&T Updated Capacity Cost Study.[23]

4.7.10. ISUP Message Length, Bytes

Definition: The average number of bytes in each ISUP (ISDN User Part) message.

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[22] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 24.

[23] Brand, at al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 25.

Default Value:

ISUP Message Length
25 bytes

Support: Bellcore Technical Reference TR-NWT-000317, Appendix A, shows that 25 bytes per message is a conservatively high figure. Northern Telecom's DMS-STP product/service information booklet shows an average ISUP message length of 25 bytes.[24] Therefore a default value of 25 average bytes per message is appropriate for use in the HAI Model.

4.7.11. TCAP Messages per Transaction

Definition: The number of Transaction Capabilities Application Part (TCAP) messages required per Service Control Point (SCP) database query. A TCAP message is a message between a switch and a database that is necessary to provide the switch with additional information prior to setting up a call or completing a call.

Default Value:

TCAP Messages per Transaction
2

Support: AT&T Updated Capacity Cost Study .[25]

4.7.12. TCAP Message Length, Bytes

Definition: The average length of a TCAP message.

Default Value:

TCAP Message Length
100 bytes

Support: Bellcore Technical Reference TR-NWT-000317, Appendix A, shows that 100 bytes per message is a conservatively high figure. Northern Telecom's DMS-STP product/service information booklet shows an average TCAP message length of 85 bytes.[26]

4.7.13. Fraction of BHCA Requiring TCAP

Definition: The percentage of BHCAs that require a database query, and thus generate TCAP messages.

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[24] Northern Telecom, *DMS-STP Planner 1995, Product/Service Information, 57005.16, Issue 1*, April, 1995, p.13.

[25] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 25.

[26] DMS-STP Planner 1995, p.13.

Default Value:

Fraction of BHCA Requiring TCAP
0.10

Support: The AT&T Updated Capacity Cost Study assumes that 50% of all calls require a database query, but that is not an appropriate number to use in the HM because a substantial fraction of IXC calls are toll-free (800) calls.[27] When reduced to reflect the fact that a large majority of calls handled by the LECs are local calls that do not require such a database query, the 50% would be less than 10%; HAI has used the 10% default as a conservatively high estimate.

4.7.14. SCP Investment per Transaction per Second

Definition: The investment in the SCP associated with database queries, or transactions, stated as the investment required per transaction per second. For example, if the default of $20,000 is assumed, an SCP required to handle 100 transactions per second would require a 2 million dollar ($20,000 times 100) investment.

Default Value:

SCP Investment per Transaction, per Second
$20,000

Support: AT&T Updated Capacity Cost Study uses a default value of $30,000 from the 1990 study, but notes that this is "conservatively high because of the industry's advances in this area and the resulting decrease in technology costs since the 1990 study." [28] The default value used in the HM represents the judgment of HAI as to the reduction of such processing costs since then.

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[27] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 25.

[28] Brand, et al., *"An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p. 27.

4.8. OS AND PUBLIC TELEPHONE

4.8.1. Investment per Operator Position

Definition: The investment per computer required for each operator position.

Default Value:

Investment per Operator Position
$6,400

Support: Based on AT&T experience in the long distance business.

4.8.2. Maximum Utilization per Position, CCS

Definition: The estimated maximum number of CCS that one operator position can handle during the busy hour.

Default Value:

Maximum Utilization per Position
32 CCS

Support: Industry experience and expertise of HAI in conjunction with subject matter experts.

4.8.3. Operator Intervention Factor

Definition: The percentage of all operator-assisted calls that require operator intervention, expressed as 1 out of every N calls, where N is the value of the input. Given the default values for operator-assisted calls, this parameter means that 1/10, or 10%, of the assisted calls actually require manual intervention of an operator, as opposed to *automated* operator assistance for credit card verification, etc.

Default Value:

Operator Intervention Factor
10

Support: Industry experience and expertise of HAI.

4.8.4. Public Telephone Equipment Investment per Station

Definition: The weighted average cost of a public telephone and pedestal (coin/non-coin and indoor/outdoor).

Default Value:

Public Telephone Equipment Investment, per Station
$760

Support: New England Incremental Cost Study.[29]

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[29] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 90.

4.9. ICO PARAMETERS

4.9.1. ICO STP Investment, per Line

Definition: The surrogate value for equivalent per line investment in STPs by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

ICO STP Investment per Line
$5.50

Support: The average STP investment per line estimated by the HAI Model for all states, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.2. ICO Local Tandem Investment, per Line

Definition: The surrogate value for the per line investment in a local tandem switch by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO Local Tandem Investment
$1.90

Support: The average local tandem investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.3. ICO OS Tandem Investment, per Line

Definition: The surrogate value for the per line investment in an Operator Services tandem switch by a small independent telephone company (ICO),that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO OS Tandem Investment
$0.80

Support: The average OS tandem investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.4. ICO SCP Investment, per Line

Definition: The surrogate value for the per line investment in a SCP by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO SCP Investment
$2.50

Support: The average SCP investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.5. ICO STP/SCP Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in an STP/SCP wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line STP / SCP Wire Center Investment
$0.40

Support: The average STP/SCP wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.6. ICO Local Tandem Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in a local tandem wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO Local Tandem Wire Center Investment
$2.50

Support: The average local tandem wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.7. ICO OS Tandem Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in a operator services tandem wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO OS Tandem Wire Center Investment
$1.00

Support: The average OS tandem wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.8. ICO C-Link / Tandem A-Link Investment, per Line

Definition: The surrogate value for the per line investment in a C-link / tandem A-link by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO C-Link / Tandem A-Link Investment
$0.30

Support: The average C-Link / tandem A-link investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.9. Equivalent Facility Investment per DS0

Definition: The per-DS0 surrogate facilities investment by a small ICO for dedicated circuits between an end office and tandem switch belonging to the BOC (or other large LEC) on which the ICO relies for interoffice connectivity.

Default Value:

Equivalent Facility Investment per DS0
$138.08

Support: The model computes the explicit investment required for facilities and terminal equipment connecting the ICO wire center with the nearest BOC wire center, then uses this parameter to separately compute a per-DS0 equivalent facilities investment in BOC dedicated circuits between the BOC wire center and the BOC tandem. The default value is the nationwide average BOC investment in the dedicated transport UNE (part of transport network elements) as calculated by the Model. Alternatively, the user can input the state-specific value that results from running the model for the BOC in question.

4.9.10. Equivalent Terminal Investment per DS0

Definition: The per-DS0 surrogate investment by a small ICO for terminal equipment used on dedicated circuits between an end office and tandem switch belonging to the BOC (or other large LEC) on which the ICO relies for interoffice connectivity.

Default Value:

Equivalent Terminal Investment per DS0
$111.62

Support: In addition to the equivalent facilities investment incurred by an ICO for the BOC end office to tandem dedicated circuits, the model uses this parameter to separately compute a per-DS0 equivalent investment in the terminal equipment used on the dedicated circuits. The default value is the nationwide average BOC investment in the dedicated transmission terminal UNE (part of transport network elements) as

calculated by the Model. Alternatively, the user can input the state-specific value that results from running the model for the BOC in question.

4.10. HOST – REMOTE ASSIGNMENT

4.10.1. Host – Remote CLLI Assignments

Definition: An input form consisting of parameters that allow the user to specify the set of host and remote wire centers, and establish the relationships between remotes and their serving host, using the CLLI codes of the respective switches. In the default mode, HM 5.0a does not make such designations or identify such relationships.

Default Value:

Host – Remote CLLI Assignments
No host-remote relationships defined

Support: These parameters are provided to give the user the means to establish host-remote relationships.

4.10.2. Host – Remote Assignment Enable

Definition: An option that, if enabled, instructs the model to perform switching calculations based on the host-remote relationships defined by Parameter 4.10.1. If enabled, 1) the investment in host/remote combinations are distributed equally among all lines served by the combination, 2) the cost of umbilical trunks between remotes and hosts is modeled explicitly, and 3) the host and remotes will be connected on a local SONET ring.

Default Value:

Host – Remote Assignment Flag
Disabled

4.11. HOST - REMOTE INVESTMENT

4.11.1. Line Sizes

Definition: The line size designations used to specify fixed and per line investments for stand alone, host and remote switches.

Default Values:

Line Size
0
640
5,000

10,000

Support: The HAI Model allows the user to specify the method of computing end office switching investments which, for host, remote, and standalone switches are specified by switch line size. The normal mode of operation in the Model aggregates switch investment as a function of switch line size. The user defined host/remote/standalone switch assignments will allow the user to define the switch investment with explicit identification of host/remote systems.

4.11.2. Fixed and per Line Investments

Definition: The fixed and per line investments included in the function that calculates the per line switching investment as a function of switch line size for host, remote, and stand alone switches, expressed separately for BOCs and large independents and for small independents. The cost function for each type of switch and each type of telephone company is assumed to have the form $A + B * x$, where A is the fixed investment, B is the per-line investment, and x is the number of lines.

Default Value:

Fixed and per Line Investments for Standalone, Host and Remote Switches						
BOCs and Large ICOs						
Line Size	Standalone fixed investment	Host fixed investment	Remote fixed investment	Standalone per line investment	Host per line investment	Remote per line investment
0	$175,000	$183,750	$10,000	$75	$75	$85
640	$175,000	$183,750	$55,000	$75	$75	$83
5,000	$175,000	$183,750	$70,000	$75	$75	$85
10,000	$475,000	$498,750	$225,000	$73	$73	$70
Small ICOs						
Line Size	Standalone fixed investment	Host fixed investment	Remote fixed investment	Standalone per line investment	Host per line investment	Remote per line investment
0	$300,001	$315,001	$17,143	$129	$129	$146
640	$300,001	$315,001	$94,286	$129	$129	$141
5,000	$300,001	$315,001	$120,000	$129	$129	$146
10,000	$814,289	$855,003	$385,716	$124	$124	$120

Support: The default values are assembled on a forward-looking basis and are derived on the basis of a forced amalgam of host, remote and standalone switch investments. This system of derived costs does not reflect a detailed analysis of prices. The default values are computed from an amalgamated process, whereby the three categories of switch investments are derived as a function of three representative curves, generated by separate line size, and when considered together yield the same result as the cost function for amalgamated switches.

5. EXPENSE

5.1. COST OF CAPITAL AND CAPITAL STRUCTURE

Definition: The capital cost structure, including the debt/equity ratio, cost of debt, and return on equity, that makes up the overall cost of capital.

Default Values:

Cost of Capital	
Debt percent	0.450
Cost of debt	0.077
Cost of equity	0.119
Weighted average Cost of capital	0.1001

Support: Based on FCC-approved cost of capital methodology using 1996 financial data and AT&T and MCI-sponsored DCF and CAPM analyses calculating the RBOCs' cost of capital. See, for example, "Statement of Matthew I. Kahal Concerning Cost of Capital," In the Matter of Rate of Return Prescription for Local Exchange Carriers," File No. AAD95-172, March 11, 1996. See also AT&T ex parte filing of February 12, 1997, "Estimating the Cost of Capital of Local Telephone Companies for the Provision of Network Elements," by Bradford Cornell, September, 1996.

5.2. DEPRECIATION AND NET SALVAGE

Definition: The economic life and net salvage value of various network plant categories.

Default Values:

Plant Type	Economic Life	Net Salvage %
motor vehicles	8.24	11.21
garage work equipment	12.22	-10.71
other work equipment	13.04	3.21
buildings	46.93	1.87
furniture	15.92	6.88
office support equipment	10.78	6.91
company comm. Equipment	7.40	3.76
general purpose computers	6.12	3.73
digital electronic switching	16.17	2.97
operator systems	9.41	-0.82
digital circuit equipment	10.24	-1.69
public telephone term. Equipment	7.60	7.97
poles	30.25	-89.98
aerial cable, metallic	20.61	-23.03
aerial cable, non metallic	26.14	-17.53
underground cable, metallic	25.00	-18.26
underground cable, non metallic	26.45	-14.58
buried cable, metallic	21.57	-8.39
buried cable, non metallic	25.91	-8.58
intrabuilding cable, metallic	18.18	-15.74
intrabuilding cable, non metallic	26.11	-10.52
conduit systems	56.19	-10.34

Support: The default values are the weighted average set of projected depreciation lives, and net salvage percentages, coming from 76 LEC study areas including all the BOCs, SNET, Cincinnati Bell, and numerous GTE and United companies. Weighting is based on total lines per operating company. The projected lives and salvage values are determined in a triennial review process involving each state PUC, the FCC, and the LEC to establish unique state-and-operating-company-specific depreciation schedules. See, FCC Public Notice D.A. #'s 95-1635, 93-970, 96-1175, 94-856, 95-1712. NID and SAI lives are calculated as the average life of metallic cable, since lives are not separately specified for those plant categories and they are classified as outside plant.

5.3. EXPENSE ASSIGNMENT

Definition: The fraction of certain categories of indirect expenses, including the loop component of general support, as well as network operations, other taxes, and variable overhead, that are assigned to loop UNEs (distribution, concentrator, feeder and NID), and thus to universal service, on a per-line basis, rather than the default assignment based on the relative proportions of the direct costs associated with these UNEs.

Default Value

Expense Assignment	Percent to be assigned per line
General Support Loops	
Furniture – Capital Costs	0 %
Furniture – Expenses	0 %
Office Equipment – Capital Costs	0 %
Office Equipment – Expenses	0 %
General Purpose Computer – Capital Costs	0 %
General Purpose Computer – Expenses	0 %
Motor Vehicles – Capital Costs	0 %
Motor Vehicles – Expenses	0 %
Buildings – Capital Costs	0 %
Buildings – Expenses	0 %
Garage Work Equipment – Capital Costs	0 %
Garage Work Equipment – Expenses	0 %
Other Work Equipment – Capital Costs	0 %
Other Work Equipment – Expenses	0 %
Network Operations	0 %
Other Taxes	0 %
Variable Overhead	0 %

Support: the default assumption is that these costs are most appropriately assigned in proportion to the identified direct costs, not on a per-line basis.

5.4. STRUCTURE SHARING FRACTIONS

Definition: The fraction of investment in distribution and feeder poles and trenching that is assigned to LECs. The remainder is attributed to other utilities/carriers.

Default Values:

Structure Percent Assigned to Telephone Company						
	Distribution			Feeder		
Density Zone	Aerial	Buried	Underground	Aerial	Buried	Underground
0-5	.50	.33	1.00	.50	.40	.50
5-100	.33	.33	.50	.33	.40	.50
100-200	.25	.33	.50	.25	.40	.40
200-650	.25	.33	.50	.25	.40	.33
650-850	.25	.33	.40	.25	.40	.33
850-2,550	.25	.33	.33	.25	.40	.33
2,550-5,000	.25	.33	.33	.25	.40	.33
5,000-10,000	.25	.33	.33	.25	.40	.33
10,000+	.25	.33	.33	.25	.40	.33

Support: Industry experience and expertise of HAI and outside plant engineers; Montgomery County, MD Subdivision Regulations Policy Relating to Grants of Location for New Conduit Network for the Provision of Commercial Telecommunications Services; Monthly Financial Statements of the Southern California Joint Pole Committee; Conversations with representatives of local utility companies. See the structure sharing discussion in Appendix B.

5.5. OTHER EXPENSE INPUTS

5.5.1. Income Tax Rate

Definition: The combined federal and state income tax rate on earnings paid by a telephone company.

Default Value:

Income Tax Rate
39.25%

Support: Based on a nationwide average of composite federal and state tax rates.

5.5.2. Corporate Overhead Factor

Definition: Forward-looking corporate overhead costs, expressed as a fraction of the sum of all capital costs and operations expenses calculated by the model.

Default Value:

Overhead Factor
10.4%

Support: Based on data from AT&T's Form M. See, also earlier ex parte submission by AT&T dated March 18, 1997 and Appendix C.

5.5.3. Other Taxes Factor

Definition: Operating taxes (primarily gross receipts and property taxes) paid by a telephone company in addition to federal and state income taxes.

Default Value:

Other Taxes Factor
5%

Support: This is the average for all Tier I LECs, expressed as a percentage of total revenue. Revenue and tax data are taken from the 1996 ARMIS report 43-03. See, also Appendix B.

5.5.4. Billing/Bill Inquiry per Line per Month

Definition:

The cost of bill generation and billing inquiries for end users, expressed as an amount per line per month.

Default Value:

Billing / Bill Inquiry per line per month
$1.22

Support: Based on data found in the New England Incremental Cost Study, section for billing and bill inquiry where unit costs are developed. This study uses marginal costing techniques, rather than TSLRIC. Therefore, billing/bill inquiry-specific fixed costs were added to conform with TSLRIC principles.[30]

To compute this value from the NET study, the base monthly cost for residential access lines is divided by the base demand (lines) for both bill inquiry (p. 122) and bill production (p. 126). The resulting per-line values are added together to arrive at the total billing/bill inquiry cost per line per month.

5.5.5. Directory Listing per Line per Month

Definition: The monthly cost of creating and maintaining white pages listings on a per line, per month basis for Universal Service Fund purposes.

Default Value:

Directory Listing per line per month
$0.00

Support: Because the FCC and Joint Board have determined that white pages listings are not an element of supported Universal Service, this value is set to default to zero. HAI estimates that the cost of maintaining a white page listing per line is $0.15 per month.

5.5.6. Forward-Looking Network Operations Factor

Definition: The forward-looking factor applied to a specific category of expenses reported in ARMIS called Network Operations. The factor is expressed as the percentage of current ARMIS-reported Network Operations costs per line.

Default Value:

Forward Looking Network Operations Factor
50%

Support: ARMIS-based network operations expenses are -- by definition -- a function of telephone company embedded costs. As reported, these costs are artificially high because they reflect antiquated systems and practices that are more costly than the modern equipment and practices that the HAI Model assumes will be installed on a forward-looking basis. Furthermore, today's costs do not reflect much of the substantial savings opportunities posed by new technologies, such as new management network standards, intranets, and the like. See Appendix D for a more detailed discussion of the savings opportunities associated with network operations.

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[30] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 122, 126.

5.5.7. Alternative Central Office Switching Expense Factor

Definition: The expense to investment ratio for digital switching equipment, used as an alternative to the ARMIS expense ratio, reflecting forward looking rather than embedded costs. Thus, this factor multiplies the calculated investment in digital switching in order to determine the monthly expense associated with digital switching. This factor is not intended to capture the cost of software upgrades to the switch, as all switching software is part of the capital value inputs to HM 5.0a.

Default Value:

Alternative Central Office Switching Expense Factor
2.69%

Support: New England Incremental Cost Study.[31]

5.5.8. Alternative Circuit Equipment Factor

Definition: The expense to investment ratio for all circuit equipment (as categorized by LECs in their ARMIS reports), used as an alternative to the ARMIS expense ratio to reflect forward looking rather than embedded costs.

Default Value:

Alternative Circuit Equipment Factor
0.0153

Support: New England Incremental Cost Study.[32]

5.5.9. End Office Non Line-Port Cost Fraction

Definition: The fraction of the total investment in digital switching that is assumed to be not related to the connection of lines to the switch.

Default Value:

End Office Non Line-Port Cost Fraction
70%

Support: This factor is a HAI estimate of the average over several different switching technologies.

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[31] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 394

[32] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 394

5.5.10. Monthly LNP Cost, per Line

Definition: The estimated cost of permanent Local Number Portability (LNP), expressed on a per-line, per-month basis, including the costs of implementing and maintaining the service. This is included in the USF calculations only, not the UNE rates, because it will be included in the definition of universal service once the service is implemented.

Default Value:

Per Line Monthly LNP Cost
$0.25

Support: This estimate is based on an ex parte submission by AT&T to the FCC in CC Docket No. 95-116, dated May 22, 1996.

5.5.11. Carrier-Carrier Customer Service, per Line, per Year

Definition: The yearly amount of customer operations expense associated with the provision of unbundled network elements by the LECs to carriers who purchase those elements.

Default Value:

Carrier-Carrier Customer Service per line
$1.69

Support: This calculation is based on data drawn from LEC ARMIS accounts 7150, 7170, 7190 and 7270 reported by all Tier I LECs in 1996. To calculate this charge, the amounts shown for each Tier 1 LEC in the referenced accounts are summed across the accounts and across all LECs, divided by the number of access lines reported by those LECs in order to express the result on a per-line basis, and multiplied by 70% to reflect forward-looking efficiencies in the provision of network elements. See, also Appendix C.

5.5.12. NID Expense, per Line, per Year

Definition: The estimated annual NID expense on a per line basis, based on an analysis of ARMIS data modified to reflect forward-looking costs. This is for the NID only, not the drop wire, which is included in the ARMIS cable and wire account.

Default Value:

NID Expense per line per year
$1.00

Support: The opinion of outside plant experts indicate a failure rate of less than 0.25 per 100 lines per month, or 3 percent per year. At a replacement cost of $29, this would yield an annual cost of $0.87. Therefore, the current default value is conservatively high.

5.5.13. DS-0/DS-1 Terminal Factor

Definition: The relative terminal investment per DS-0, between the DS-1 and DS-0 levels.

Default Value:

DS-0 / DS-1 Terminal Factor
12.4

Support: The computed ratio for investment per DS-0 when provided in a DS-0 level signal, to per DS-0 investment when provided in a DS-1 level signal, based on transmission terminal investments (see 4.4.1 for terminal investments).

5.5.14. DS-1/DS-3 Terminal Factor

Definition: The relative investment per DS-0, between the DS-3 and DS-1 levels.

Default Value:

DS-1 / DS-3 Terminal Factor
9.9

Support: The computed ratio for investment per DS-0 when provided in a DS-1 level signal, to per DS-0 investment when provided in a DS-3 level signal, based on transmission terminal investments (i.e., 4.4.1).

5.5.15. Average Lines per Business Location

Definition: The average number of business lines per business location, used to calculate NID and drop cost. This parameter should be set the same as 2.2.5.

Default Value:

Average Business Lines per Location
4

Support: *{NOTE: The discussion in Section 2.2.5. [Distribution] is reproduced here for ease of use.}*

The number of lines per business location estimated by HAI is based on data in the *1995 Common Carrier Statistics* and the *1995 Statistical Abstract of the United States*.

5.5.16. Average Trunk Utilization

Definition: The 24 hour average utilization of an interoffice trunk.

Default Value:

Average Trunk Utilization
0.30

Support: AT&T Capacity Cost Study.[33]

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[33] Blake, et al., *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, p.4.

6. EXCAVATION AND RESTORATION

6.1. UNDERGROUND EXCAVATION

Definition: The cost per foot to dig a trench in connection with building an underground conduit system to facilitate the placement of underground cables. Cutting the surface, placing the 4" PVC conduit pipes, backfilling the trench with appropriately screened fill, and restoring surface conditions is covered in the following section titled, "Underground Restoration Cost per Foot". These two sections do not include the material cost of the PVC conduit pipe, which is covered under "Conduit Material Investment per foot", and is affected by the number of cables placed in a conduit run, and the number of "Spare tubes per Route."

Default Values:

Underground Excavation Costs per Foot						
Density	Normal Trenching		Backhoe		Hand Trench	
Range	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot
0-5	*54%*	$1.90	45%	$3.00	1%	$5.00
5-100	*54%*	$1.90	45%	$3.00	1%	$5.00
100-200	*54%*	$1.90	45%	$3.00	1%	$5.00
200-650	*52%*	$1.90	45%	$3.00	3%	$5.00
650-850	*52%*	$1.95	45%	$3.00	3%	$5.00
850-2,550	*50%*	$2.15	45%	$3.00	5%	$5.00
2,550-5,000	*35%*	$2.15	55%	$3.00	10%	$5.00
5,000-10,000	*23%*	$6.00	67%	$20.00	10%	$10.00
10,000+	*16%*	$6.00	72%	$30.00	12%	$18.00

Note: Fraction % for Normal Trenching is the fraction remaining after subtracting Backhoe % & Trench %.

Support: See discussion in Section 6.2.

6.2. UNDERGROUND RESTORATION

Definition: The cost per foot to cut the surface, place the 4" PVC conduit pipes, backfill the trench with appropriately screened fill, and restore surface conditions. Digging a trench in connection with building an underground conduit system to facilitate the placement of underground cables is covered in the preceding section titled, "Underground Excavation Cost per Foot". These two sections do not include the material cost of the PVC conduit pipe, which is covered under "Conduit Material Investment per foot", and is affected by the number of cables placed in a conduit run, and the number of "Spare tubes per Route."

Default Values:

Underground Restoration Costs per Foot												
	Cut/Restore Asphalt		Cut/Restore Concrete		Cut/Restore Sod		Simple Backfill		Conduit Placement & Stabilization			
Density Range	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Pave-ment/ft	Frac-tion	Dirt/ft
0-5	55%	$6.00	10%	$9.00	1%	$1.00	*34%*	$0.15	*65%*	$5.00	*35%*	$1.00
5-100	55%	$6.00	10%	$9.00	1%	$1.00	*34%*	$0.15	*65%*	$5.00	*35%*	$1.00
100-200	55%	$6.00	10%	$9.00	1%	$1.00	*34%*	$0.15	*65%*	$5.00	*35%*	$1.00
200-650	65%	$6.00	10%	$9.00	3%	$1.00	*22%*	$0.15	*75%*	$5.00	*25%*	$1.00
650-850	70%	$6.00	10%	$9.00	4%	$1.00	*16%*	$0.15	*80%*	$5.00	*20%*	$1.00
850-2,550	75%	$6.00	10%	$9.00	6%	$1.00	*9%*	$0.15	*85%*	$9.00	*15%*	$4.00
2,550-5,000	75%	$6.00	15%	$9.00	4%	$1.00	*6%*	$0.15	*90%*	$13.00	*10%*	$11.00
5,000-10,000	80%	$18.00	15%	$21.00	2%	$1.00	*3%*	$0.15	*95%*	$17.00	*5%*	$12.00
10,000+	82%	$30.00	16%	$36.00	0%	$1.00	*2%*	$0.15	*98%*	$20.00	*2%*	$16.00

Note: Fraction % for Simple Backfill is the fraction remaining after subtracting Asphalt % & Concrete % & Sod %.
Fraction % for Conduit Placement & Stabilization for Pavement is Asphalt % + Concrete %.
Fraction % for Conduit Placement & Stabilization for Dirt is Sod % + Simple Backfill %.

Support: The costs reflect a mixture of different types of placement activities.

Note: Use of underground conduit structure for distribution should be infrequent, especially in the lower density zones. Although use of conduit for distribution cable in lower density zones is not expected, default prices are shown, should a user elect to change parameters for percent underground, aerial, and buried structure allowed by the HM 5.0a model structure.

Excavation and restoral costs are significantly higher in the two highest density zones to care for working within congested subsurface facility conditions, handling traffic control, work hour restrictions, concrete encasement of ducts, and atypical trench depths.
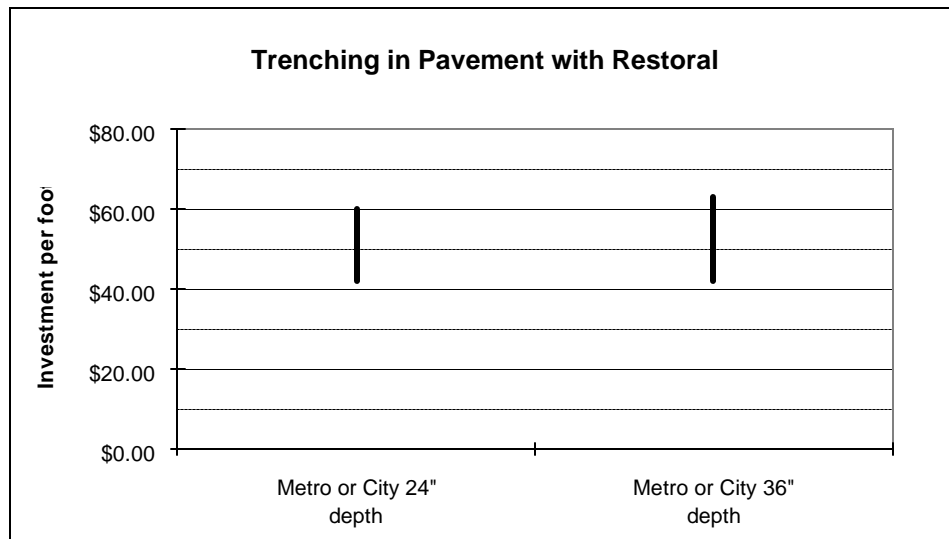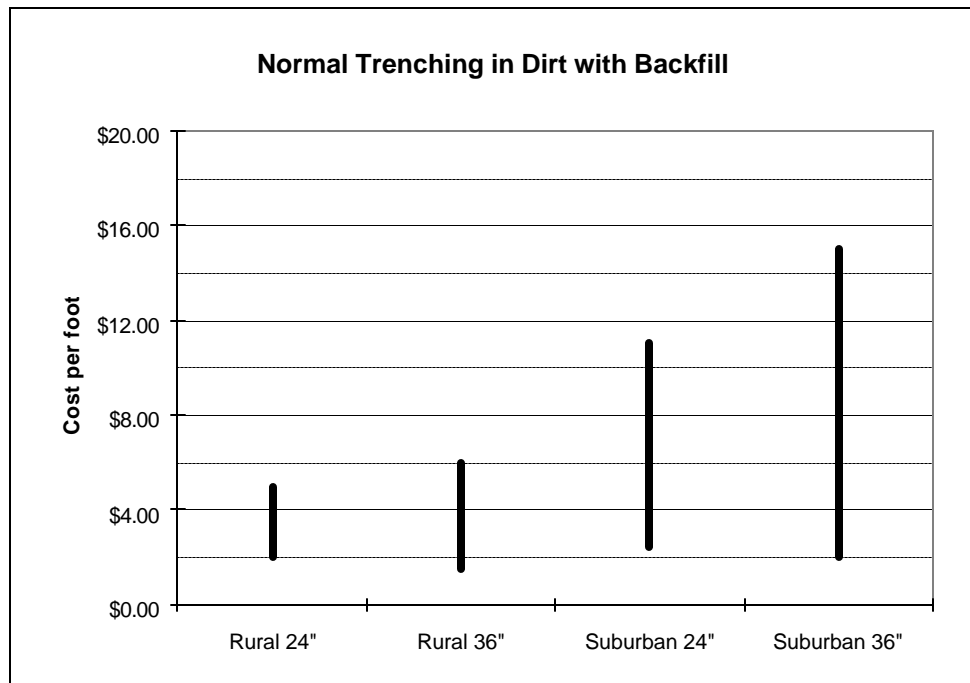
A compound weighted cost for conduit excavation, placement and restoral can be calculated by multiplying the individual columns shown above and in the immediately preceding section, "Underground Excavation Costs per Foot". Performing such calculations using the default values shown would provide the following composite costs by density zone.

The percentages for Underground Excavation Costs total to 100%, for Restoration (Asphalt + Concrete + Sod + Simple Backfill) total to 100%, and for Conduit Placement & Stabilization total to 100%, since each is a discrete function.

Underground Excavation, Restoration, and Conduit Placement Cost per Foot	
Density Zone	Cost Per Foot
0-5	$10.29
5-100	$10.29
100-200	$10.29
200-650	$11.35
650-850	$11.88
850-2,550	$16.40
2,550-5,000	$21.60
5,000-10,000	$50.10
10,000+	$75.00

Costs for various trenching methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[34]. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries are revealed in the following charts. Note that this survey demonstrates that costs do not vary significantly between buried placements at 24" underground versus 36" underground. Therefore the HAI Model assumes an average placement depth ranging from 24" to 36", averaging 30".

Conduit placement cost is essentially the same, whether the conduit is used to house distribution cable, feeder cable, interoffice cable, or other telecommunication carrier cable, including CATV.

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[34] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.

Normal Trenching in Dirt with Backfill

Cost per foot

| | Rural 24" | Rural 36" | Suburban 24" | Suburban 36" |

Trenching in Pavement with Restoral

Cost per foot

| | Metro 24" | Metro 36" |
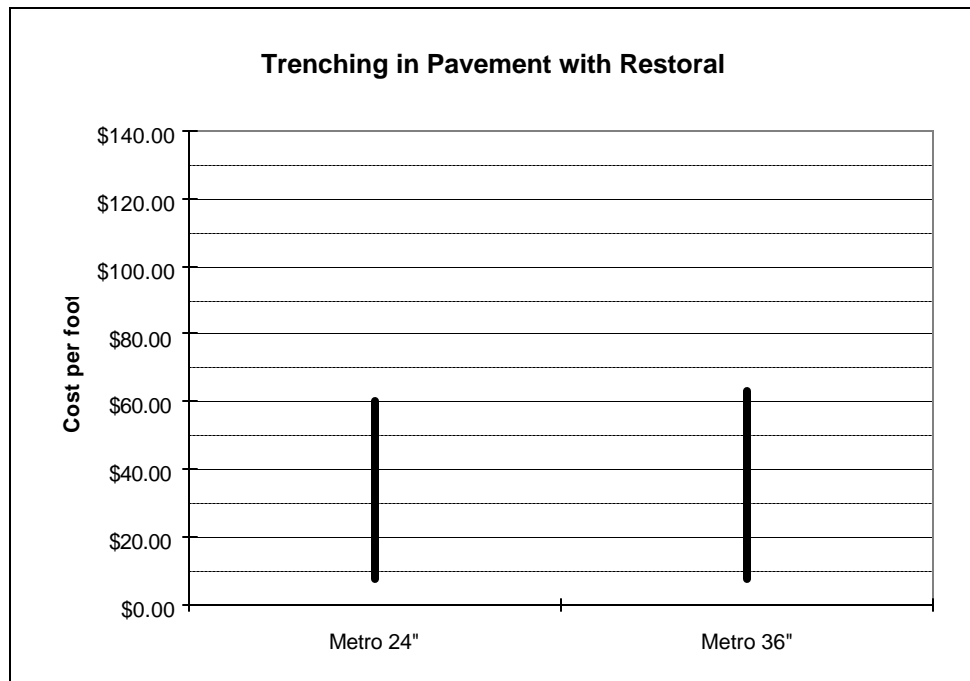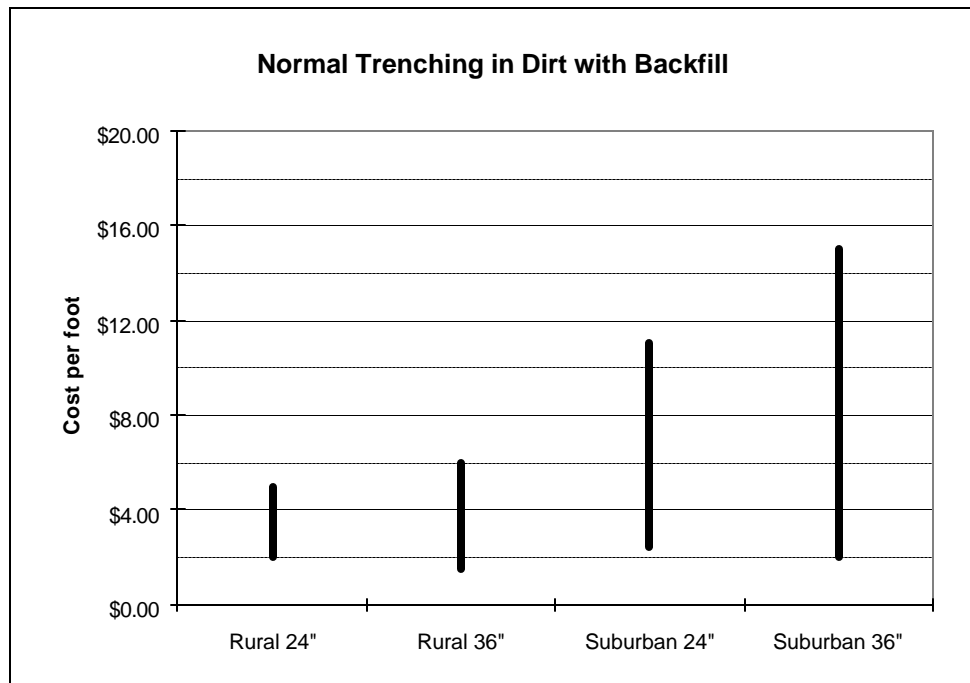
6.3. BURIED EXCAVATION

Definition: The cost per foot to dig a trench to allow buried placement of cables, or the plowing of one or more cables into the earth using a single or multiple sheath plow.

Default Values:

Buried Excavation Costs per Foot												
	Plow		Normal Trench		Backhoe		Hand Trench		Bore Cable		Push Pipe/ Pull Cable	
Density Range	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot
0-5	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2 %	$6.00
5-100	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2%	$6.00
100-200	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2%	$6.00
200-650	50%	$0.80	*37%*	$1.90	10%	$3.00	1%	$5.00	0%	$11.00	2%	$6.00
650-850	35%	$0.80	*51%*	$1.95	10%	$3.00	2%	$5.00	0%	$11.00	2%	$6.00
850-2,550	20%	$1.20	*59%*	$2.15	10%	$3.00	4%	$5.00	3%	$11.00	4%	$6.00
2,550-5,000	0%	$1.20	*76%*	$2.15	10%	$3.00	5%	$5.00	4%	$11.00	5%	$6.00
5,000-10,000	0%	$1.20	*73%*	$6.00	10%	$20.00	6%	$10.00	5%	$11.00	6%	$6.00
10,000+	0%	$1.20	*54%*	$15.00	25%	$30.00	10%	$18.00	5%	$18.00	6%	$24.00

Note: Fraction % for Normal Trenching is the fraction remaining after subtracting Plow %, Backhoe %, Hand Trench %, Bore Cable % and Push Pipe / Pull Cable % from 100%.

Support: See discussion in Section 6.4.

6.4. BURIED INSTALLATION AND RESTORATION

Definition: The cost per foot to push pipe under pavement , or the costs per foot to cut the surface, place cable in a trench, backfill the trench with appropriately screened fill, and restore surface conditions. Digging a trench in connection with placing buried cable is covered in the preceding section titled, "Buried Excavation Cost per Foot".

Default Values:

Buried Installation and Restoration Costs per Foot								
	Cut/Restore Asphalt		Cut/Restore Concrete		Cut/Restore Sod		Simple Backfill		Restoral Not Req'd
Density Range	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Fraction
0-5	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
5-100	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
100-200	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
200-650	3%	$6.00	1%	$9.00	2%	$1.00	42%	$0.15	52%
650-850	3%	$6.00	1%	$9.00	2%	$1.00	57%	$0.15	37%
850-2,550	5%	$6.00	3%	$9.00	35%	$1.00	30%	$0.15	27%
2,550-5,000	8%	$6.00	5%	$9.00	35%	$1.00	43%	$0.15	9%
5,000-10,000	18%	$18.00	8%	$21.00	11%	$1.00	52%	$0.15	11%
10,000+	60%	$30.00	20%	$36.00	5%	$1.00	4%	$0.15	11%

Note: Note: Restoral is not required for plowing, boring, or pushing pipe & pulling cable. Fraction for Simple Backfill is the fraction remaining after subtracting the Restoral Not Required fraction and the cut/restore activities fractions from 100%.

Support:
The costs reflect a mixture of different types of placement activities.

Excavation and restoral costs are significantly higher in the two highest density zones to care for working within congested subsurface facility conditions, handling traffic control, work hour restrictions, and atypical trench depths.

A compound weighted cost for conduit excavation, placement and restoral can be calculated by multiplying the individual columns shown above and in the immediately preceding section, "Buried Excavation Costs per Foot". Performing such calculations using the default values shown would provide the following composite costs by density zone.

Buried Excavation, Installation, and Restoration Cost per Foot	
Density Zone	Cost Per Foot
0-5	$1.77
5-100	$1.77
100-200	$1.77
200-650	$1.93
650-850	$2.17
850-2,550	$3.54
2,550-5,000	$4.27
5,000-10,000	$13.00
10,000+	$45.00

Costs for various excavation methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[35]. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries are revealed in the following charts. Note that this survey demonstrates that costs do not vary significantly between buried placements at 24" underground versus 36" underground. Therefore the HAI Model assumes an average placement depth ranging from 24" to 36", averaging 30".

Plow Cable

[35] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.

Normal Trenching in Dirt with Backfill

Cost per foot

$20.00	
$16.00	
$12.00	
$8.00	
$4.00	
$0.00	

Rural 24"   Rural 36"   Suburban 24"   Suburban 36"

Trenching in Pavement with Restoral

Investment per foot

$80.00	
$60.00	
$40.00	
$20.00	
$0.00	

Metro or City 24"
depth

Metro or City 36"
depth

6.5. SURFACE TEXTURE MULTIPLIER

Definition: The increase in placement cost attributable to the soil condition in a main cluster and its associated outlier clusters, expressed as a multiplier of a fraction of all buried or underground structure excavation components in the clusters. The multiplier appears in the "Effect" column, and the fraction appears in the "Fraction of Cluster Affected" column. The surface conditions are determined from the CBG to which the clusters belong. The table lists effects in alphabetical order by Texture Code.

Default Values:

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00		Blank
1.00	1.00	BY	Bouldery
1.00	1.00	BY-COS	Bouldery Coarse Sand
1.00	1.00	BY-FSL	Bouldery & Fine Sandy Loam
1.00	1.00	BY-L	Bouldery & Loam
1.00	1.00	BY-LS	Bouldery & Sandy Loam
1.00	1.00	BY-SICL	Bouldery & Silty Clay Loam
1.00	1.00	BY-SL	Bouldery & Sandy Loam
1.00	1.10	BYV	Very Bouldery
1.00	1.10	BYV-FSL	Very Bouldery & Fine Sandy Loam
1.00	1.10	BYV-L	Very Bouldery & Loamy
1.00	1.10	BYV-LS	Very Bouldery & Loamy Sand
1.00	1.10	BYV-SIL	Very Bouldery & Silt
1.00	1.10	BYV-SL	Very Bouldery & Sandy Loam
1.00	1.30	BYX	Extremely Bouldery
1.00	1.30	BYX-FSL	Extremely Bouldery & Fine Sandy Loam
1.00	1.30	BYX-L	Extremely Bouldery & Loamy
1.00	1.30	BYX-SIL	Extremely Bouldery & Silt Loam
1.00	1.30	BYX-SL	Extremely Bouldery & Sandy Loam
1.00	1.00	C	Clay
1.00	1.00	CB	Cobbly
1.00	1.00	CB-C	Cobbly & Clay
1.00	1.00	CB-CL	Cobbly & Clay Loam
1.00	1.00	CB-COSL	Cobbly & Coarse Sandy Loam
1.00	1.10	CB-FS	Cobbly & Fine Sand
1.00	1.10	CB-FSL	Cobbly & Fine Sandy Loam
1.00	1.00	CB-L	Cobbly & Loamy
1.00	1.00	CB-LCOS	Cobbly & Loamy Coarse Sand
1.00	1.00	CB-LS	Cobbly & Loamy Sand
1.00	1.10	CB-S	Cobbly & Sand
1.00	1.00	CB-SCL	Cobbly & Sandy Clay Loam
1.00	1.00	CB-SICL	Cobbly & Silty Clay Loam
1.00	1.00	CB-SIL	Cobbly & Silt Loam
1.00	1.10	CB-SL	Cobbly & Sandy Loam
1.00	1.00	CBA	Angular Cobbly
1.00	1.10	CBA-FSL	Angular Cobbly & Fine Sandy Loam

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.20	CBV	Very Cobbly
1.00	1.20	CBV-C	Very Cobbly & Clay
1.00	1.20	CBV-CL	Very Cobbly & Clay Loam
1.00	1.20	CBV-FSL	Very Cobbly & Fine Sandy Loam
1.00	1.20	CBV-L	Very Cobbly & Loamy
1.00	1.20	CBV-LFS	Very Cobbly & Fine Loamy Sand
1.00	1.20	CBV-LS	Very Cobbly & Loamy Sand
1.00	1.20	CBV-MUCK	Very Cobbly & Muck
1.00	1.20	CBV-SCL	Very Cobbly & Sandy Clay Loam
1.00	1.20	CBV-SIL	Very Cobbly & Silt
1.00	1.20	CBV-SL	Very Cobbly & Sandy Loam
1.00	1.20	CBV-VFS	Very Cobbly & Very Fine Sand
1.00	1.20	CBX	Extremely Cobbly
1.00	1.20	CBX-CL	Extremely Cobbly & Clay
1.00	1.20	CBX-L	Extremely Cobbly Loam
1.00	1.20	CBX-SIL	Extremely Cobbly & Silt
1.00	1.20	CBX-SL	Extremely Cobbly &Sandy Loam
1.00	1.30	CBX-VFSL	Extremely Cobbly Very Fine Sandy Loam
1.00	1.00	CE	Coprogenous Earth
1.00	1.00	CIND	Cinders
1.00	1.00	CL	Clay Loam
1.00	1.30	CM	Cemented
1.00	1.00	CN	Channery
1.00	1.00	CN-CL	Channery & Clay Loam
1.00	1.10	CN-FSL	Channery & Fine Sandy Loam
1.00	1.00	CN-L	Channery & Loam
1.00	1.00	CN-SICL	Channery & Silty Clay Loam
1.00	1.00	CN-SIL	Channery & Silty Loam
1.00	1.00	CN-SL	Channery & Sandy Loam
1.00	1.00	CNV	Very Channery
1.00	1.00	CNV-CL	Very Channery & Clay
1.00	1.00	CNV-L	Very Channery & Loam
1.00	1.00	CNV-SCL	Channery & Sandy Clay Loam
1.00	1.00	CNV-SIL	Very Channery & Silty Loam
1.00	1.00	CNV-SL	Very Channery & Sandy Loam
1.00	1.00	CNX	Extremely Channery
1.00	1.00	CNX-SL	Extremely Channery & Sandy Loam
1.00	1.00	COS	Coarse Sand
1.00	1.00	COSL	Coarse Sandy Loam
1.00	1.20	CR	Cherty
1.00	1.20	CR-L	Cherty & Loam
1.00	1.20	CR-SICL	Cherty & Silty Clay Loam
1.00	1.20	CR-SIL	Cherty & Silty Loam
1.00	1.20	CR-SL	Cherty & Sandy Loam
1.00	1.20	CRC	Coarse Cherty
1.00	1.20	CRV	Very Cherty

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.20	CRV-L	Very Cherty & Loam
1.00	1.20	CRV-SIL	Very Cherty & Silty Loam
1.00	1.30	CRX	Extremely Cherty
1.00	1.30	CRX-SIL	Extremely Cherty & Silty Loam
1.00	1.00	DE	Diatomaceous Earth
1.00	1.00	FB	Fibric Material
1.00	1.00	FINE	Fine
1.00	1.00	FL	Flaggy
1.00	1.10	FL-FSL	Flaggy & Fine Sandy Loam
1.00	1.00	FL-L	Flaggy & Loam
1.00	1.00	FL-SIC	Flaggy & Silty Clay
1.00	1.00	FL-SICL	Flaggy & Silty Clay Loam
1.00	1.00	FL-SIL	Flaggy & Silty Loam
1.00	1.00	FL-SL	Flaggy & Sandy Loam
1.00	1.10	FLV	Very Flaggy
1.00	1.10	FLV-COSL	Very Flaggy & Coarse Sandy Loam
1.00	1.10	FLV-L	Very Flaggy & Loam
1.00	1.10	FLV-SICL	Very Flaggy & Silty Clay Loam
1.00	1.10	FLV-SL	Very Flaggy & Sandy Loam
1.00	1.10	FLX	Extremely Flaggy
1.00	1.10	FLX-L	Extremely Flaggy & Loamy
1.00	1.00	FRAG	Fragmental Material
1.00	1.10	FS	Fine Sand
1.00	1.10	FSL	Fine Sandy Loam
1.00	1.00	G	Gravel
1.00	1.00	GR	Gravelly
1.00	1.00	GR-C	Gravel & Clay
1.00	1.00	GR-CL	Gravel & Clay Loam
1.00	1.00	GR-COS	Gravel & Coarse Sand
1.00	1.00	GR-COSL	Gravel & Coarse Sandy Loam
1.00	1.00	GR-FS	Gravel & Fine Sand
1.00	1.00	GR-FSL	Gravel & Fine Sandy Loam
1.00	1.00	GR-L	Gravel & Loam
1.00	1.00	GR-LCOS	Gravel & Loamy Coarse Sand
1.00	1.10	GR-LFS	Gravel & Loamy Fine Sand
1.00	1.00	GR-LS	Gravel & Loamy Sand
1.00	1.00	GR-MUCK	Gravel & Muck
1.00	1.00	GR-S	Gravel & Sand
1.00	1.00	GR-SCL	Gravel & Sandy Clay Loam
1.00	1.00	GR-SIC	Gravel & Silty Clay
1.00	1.00	GR-SICL	Gravel & Silty Clay Loam
1.00	1.00	GR-SIL	Gravel & Silty Loam
1.00	1.00	GR-SL	Gravel & Sandy Loam
1.00	1.10	GR-VFSL	Gravel & Very Fine Sandy Loam
1.00	1.00	GRC	Coarse Gravelly
1.00	1.00	GRF	Fine Gravel

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00	GRF-SIL	Fine Gravel Silty Loam
1.00	1.00	GRV	Very Gravelly
1.00	1.00	GRV-CL	Very gravelly & Clay Loam
1.00	1.00	GRV-COS	Very Gravelly & coarse Sand
1.00	1.00	GRV-COSL	Very Gravelly & coarse Sandy Loam
1.00	1.00	GRV-FSL	Very Gravelly & Fine Sandy Loam
1.00	1.00	GRV-L	Very Gravelly & Loam
1.00	1.00	GRV-LCOS	Very Gravelly & Loamy Coarse Sand
1.00	1.00	GRV-LS	Very Gravelly & Loamy Sand
1.00	1.00	GRV-S	Very Gravelly & Sand
1.00	1.00	GRV-SCL	Very Gravelly & Sandy Clay Loam
1.00	1.00	GRV-SICL	Very Gravelly & Silty Clay Loam
1.00	1.00	GRV-SIL	Very Gravelly & Silt
1.00	1.00	GRV-SL	Very Gravelly & Sandy Loam
1.00	1.00	GRV-VFS	Very Gravelly & Very Fine Sand
1.00	1.00	GRV-VFSL	Very Gravelly & Very Fine Sandy Loam
1.00	1.10	GRX	Extremely Gravelly
1.00	1.10	GRX-CL	Extremely Gravelly & Coarse Loam
1.00	1.10	GRX-COS	Extremely Gravelly & Coarse Sand
1.00	1.10	GRX-COSL	Extremely Gravelly & Coarse Sandy Loam
1.00	1.10	GRX-FSL	Extremely Gravelly & Fine Sand Loam
1.00	1.10	GRX-L	Extremely Gravelly & Loam
1.00	1.10	GRX-LCOS	Extremely Gravelly & Loamy Coarse
1.00	1.10	GRX-LS	Extremely Gravelly & Loamy Sand
1.00	1.10	GRX-S	Extremely Gravelly & Sand
1.00	1.10	GRX-SIL	Extremely Gravelly & Silty Loam
1.00	1.10	GRX-SL	Extremely Gravelly & Sandy Loam
1.00	1.20	GYP	Gypsiferous Material
1.00	1.00	HM	Hemic Material
1.00	1.50	ICE	Ice or Frozen Soil
1.00	1.20	IND	Indurated
1.00	1.00	L	Loam
1.00	1.00	LCOS	Loamy Coarse Sand
1.00	1.10	LFS	Loamy Fine Sand
1.00	1.00	LS	Loamy Sand
1.00	1.00	LVFS	Loamy Very Fine Sand
1.00	1.00	MARL	Marl
1.00	1.00	MEDIUM coarse	Medium Coarse
1.00	1.00	MK	Mucky
1.00	1.00	MK-C	Mucky Clay
1.00	1.00	MK-CL	Mucky Clay Loam
1.00	1.00	MK-FS	Muck & Fine Sand
1.00	1.00	MK-FSL	Muck & Fine Sandy Loam
1.00	1.00	MK-L	Mucky Loam
1.00	1.00	MK-LFS	Mucky Loamy Fine Sand
1.00	1.00	MK-LS	Mucky Loamy Sand

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00	MK-S	Muck & Sand
1.00	1.00	MK-SI	Mucky & Silty
1.00	1.00	MK-SICL	Mucky & Silty Clay Loam
1.00	1.00	MK-SIL	Mucky Silt
1.00	1.00	MK-SL	Mucky & Sandy Loam
1.00	1.00	MK-VFSL	Mucky & Very Fine Sandy Loam
1.00	1.00	MPT	Mucky Peat
1.00	1.00	MUCK	Muck
1.00	1.00	PEAT	Peat
1.00	1.00	PT	Peaty
1.00	1.50	RB	Rubbly
1.00	1.50	RB-FSL	Rubbly Fine Sandy Loam
1.00	1.00	S	Sand
1.00	1.00	SC	Sandy Clay
1.00	1.00	SCL	Sandy Clay Loam
1.00	1.00	SG	Sand & Gravel
1.00	1.00	SH	Shaly
1.00	1.00	SH-CL	Shaly & Clay
1.00	1.00	SH-L	Shale & Loam
1.00	1.00	SH-SICL	Shaly & Silty Clay Loam
1.00	1.00	SH-SIL	Shaly & Silt Loam
1.00	1.50	SHV	Very Shaly
1.00	1.50	SHV-CL	Very Shaly & Clay Loam
1.00	2.00	SHX	Extremely Shaly
1.00	1.00	SI	Silt
1.00	1.00	SIC	Silty Clay
1.00	1.00	SICL	Silty Clay Loam
1.00	1.00	SIL	Silt Loam
1.00	1.00	SL	Sandy Loam
1.00	1.00	SP	Sapric Material
1.00	1.00	SR	Stratified
1.00	1.00	ST	Stony
1.00	1.00	ST-C	Stony & Clay
1.00	1.00	ST-CL	Stony & Clay Loam
1.00	1.00	ST-COSL	Stony & Coarse Sandy Loam
1.00	1.10	ST-FSL	Stony & Fine Sandy Loam
1.00	1.00	ST-L	Stony & Loamy
1.00	1.00	ST-LCOS	Stony & Loamy Coarse Sand
1.00	1.10	ST-LFS	Stony & Loamy Fine Sand
1.00	1.00	ST-LS	Stony & Loamy Sand
1.00	1.00	ST-SIC	Stony & Silty Clay
1.00	1.00	ST-SICL	Stony & Silty Clay Loam
1.00	1.00	ST-SIL	Stony & Silt Loam
1.00	1.00	ST-SL	Stony & Sandy Loam
1.00	1.10	ST-VFSL	Stony & Sandy Very Fine Silty Loam
1.00	1.20	STV	Very Stony

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.20	STV-C	Very Stony & Clay
1.00	1.20	STV-CL	Very Stony & Clay Loam
1.00	1.20	STV-FSL	Very Stony & Fine Sandy Loam
1.00	1.20	STV-L	Very Stony & Loamy
1.00	1.20	STV-LFS	Very Stony & Loamy Fine Sand
1.00	1.20	STV-LS	Very Stony & Loamy Sand
1.00	1.20	STV-MPT	Very Stony & Mucky Peat
1.00	1.20	STV-MUCK	Very Stony & Muck
1.00	1.20	STV-SICL	Very Stony & Silty Clay Loam
1.00	1.20	STV-SIL	Very Stony & Silty Loam
1.00	1.20	STV-SL	Very Stony & Sandy Loam
1.00	1.20	STV-VFSL	Very Stony & Very Fine Sandy Loam
1.00	1.30	STX	Extremely Stony
1.00	1.30	STX-C	Extremely Stony & Clay
1.00	1.30	STX-CL	Extremely Stony & Clay Loam
1.00	1.30	STX-COS	Extremely Stony & Coarse Sand
1.00	1.30	STX-COSL	Extremely Stony & Coarse Sand Loam
1.00	1.30	STX-FSL	Extremely Stony & Fine Sandy Loam
1.00	1.30	STX-L	Extremely Stony & Loamy
1.00	1.30	STX-LCOS	Extremely Stony & Loamy Coarse Sand
1.00	1.30	STX-LS	Extremely Stony & Loamy Sand
1.00	1.30	STX-MUCK	Extremely Stony & Muck
1.00	1.30	STX-SIC	Extremely Stony & Silty Clay
1.00	1.30	STX-SICL	Extremely Stony & Silty Clay Loam
1.00	1.30	STX-SIL	Extremely Stony & Silty Loam
1.00	1.30	STX-SL	Extremely Stony & Sandy Loam
1.00	1.30	STX-VFSL	Extremely Stony & Very Fine Sandy Loam
1.00	3.00	SY	Slaty
1.00	3.00	SY-L	Slaty & Loam
1.00	3.00	SY-SIL	Slaty & Silty Loam
1.00	3.50	SYV	Very Slaty
1.00	4.00	SYX	Extremely Slaty
1.00	1.00	UNK	Unknown
1.00	2.00	UWB	Unweathered Bedrock
1.00	1.00	VAR	Variable
1.00	1.00	VFS	Very Fine Sand
1.00	1.00	VFSL	Very Fine Sandy loam
1.00	3.00	WB	Weathered Bedrock

Support: Discussions with excavation contractors who routinely perform work in a variety of soil conditions are reflected in the default difficulty factors listed above. Difficulty factors range from 1.00, or no additional effect, to as high as 4.0, or 400% as much as normal.

Although an engineer would normally modify plans to avoid difficult soil textures where possible, and although it is likely that population is located in portions of a CBG where conditions are less severe than is the average throughout the CBG, HM 5.0a has taken the conservative approach of assuming that the difficult terrain factors would affect 100% of the cluster.

7. REGIONAL LABOR ADJUSTMENT FACTORS

Definition: Factors that adjust a specific portion of certain investments by a labor factor adjustment that account for regional differences in the availability of trained labor, union contracts, and cost of living factors. Both the portions of different categories of investments that are affected and the size of adjustment are included as parameters.

Default Value:

Regional Labor Adjustment Factor	
Factor	1.0

Regional Labor Adjustment Factor Fraction of Installed Investment Affected	
Contractor Trenching	.125
Telco Construction – Copper	.164
Telco Construction – Fiber	.364
Telco I&M – NID & Drop	.571
Pole Placing	.518

Support: Different areas of the country are known to experience variations in wages paid to technicians, depending on availability of trained labor, union contracts, and cost of living factors. The adjustment applies only to that portion of installed costs pertaining to salaries. It does not apply to loading factors such as exempt material, construction machinery, motor vehicles, leases and rentals of special tools and work equipment, welfare, pension, unemployment insurance, workers compensation insurance, liability insurance, general contractor overheads, subcontractor overheads, and taxable and non-taxable fringe benefits.

The portions of various kinds of network investment affected by the adjustment are determined as follows. For heavy construction of outside plant cable, the model assumes a fully loaded direct labor cost of $55.00 per hour for a placing or splicing technician who receives pay of $20 per hour. For copper feeder and copper distribution cable, the HAI Model assumes that this fully loaded direct labor component accounts for 45% of the investment.

Because $20 is 36.4% of the fully loaded $55 per hour figure, the effect of the Regional Labor Adjustment Factor is 0.364 x .45, or 16.4% of the installed cost of copper cable. Therefore, the labor adjustment factor is applied to 16.4% of the installed cost of copper cable.

The labor adjustment factor also applies to pole labor, NID installation, conduit and buried placement, and drop installation. In the feeder plant, the factor applies to manhole and pullbox installation as well as to cable and other structure components.

Contract labor is used for buried trenching, conduit trenching, and manhole/pullbox excavation. Contract labor (vs. equipment + other charges) is 25% of total contractor cost. Direct salaries are 50% of the "labor & benefits" cost. The fraction of investment that represents labor cost for these items, and is, therefore, subject to the regional labor adjustment factor, is 0.25 times 0.50, or 0.125 of the trenching and excavation costs.

Once the adjustment factors are determined in this fashion, the factor is multiplied by the corresponding unit cost to determine the amount of investment affected by the adjustment. This amount is then multiplied by the specific regional labor adjustment factor to determine the modified investment. For instance, if buried installation trenching per foot is normally $1.77, the adjustment factor of 0.125 applied to this amount is $0.2213. If the regional adjustment was 1.07 (e.g., California), the increased installation cost is 0.07 times $0.2213, or $0.015.

Application of Regional Labor Adjustment Factor on Buried Installation			
Density Zone	Buried Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$1.77	0.125	$0.2213
5-100	$1.77	0.125	$0.2213
100-200	$1.77	0.125	$0.2213
200-650	$1.93	0.125	$0.2413
650-850	$2.17	0.125	$0.2713
850-2,550	$3.54	0.125	$0.4425
2,550-5,000	$4.27	0.125	$0.5338
5,000-10,000	$13.00	0.125	$1.6250
10,000+	$45.00	0.125	$5.6250

Application of Regional Labor Adjustment Factor on Conduit Installation			
Density Zone	Conduit Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$10.29	0.125	$1.2863
5-100	$10.29	0.125	$1.2863
100-200	$10.29	0.125	$1.2863
200-650	$11.35	0.125	$1.4188
650-850	$11.38	0.125	$1.4225
850-2,550	$16.40	0.125	$2.0500
2,550-5,000	$21.60	0.125	$2.7000
5,000-10,000	$50.10	0.125	$6.2625
10,000+	$75.00	0.125	$9.3750

Application of Regional Labor Adjustment Factor on Manhole Installation			
Density Zone	Manhole Excavation & Backfill	Labor Content Affected	Investment Affected per Manhole
0-5	$2,800	0.125	$350
5-100	$2,800	0.125	$350
100-200	$2,800	0.125	$350
200-650	$2,800	0.125	$350
650-850	$3,200	0.125	$400
850-2,550	$3,500	0.125	$438
2,550-5,000	$3,500	0.125	$438
5,000-10,000	$5,000	0.125	$625
10,000+	$5,000	0.125	$625

Application of Regional Labor Adjustment Factor on Fiber Pullbox Installation			
Density Zone	Pullbox Excavation & Backfill	Labor Content Affected	Investment Affected per Pullbox
0-5	$220	0.125	$27.50
5-100	$220	0.125	$27.50
100-200	$220	0.125	$27.50
200-650	$220	0.125	$27.50
650-850	$220	0.125	$27.50
850-2,550	$220	0.125	$27.50
2,550-5,000	$220	0.125	$27.50
5,000-10,000	$220	0.125	$27.50
10,000+	$220	0.125	$27.50

Application of Regional Labor Adjustment Factor on Copper Distribution Cable Installation			
Copper Distribution Cable Size	Installed Copper Distribution Cost	Labor Content Affected	Investment Affected per Foot
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41
50	$1.63	0.164	$0.27
25	$1.19	0.164	$0.20
12	$0.76	0.164	$0.12
6	$0.63	0.164	$0.10

Application of Regional Labor Adjustment Factor on Copper Riser Cable Installation			
Copper Distribution Cable Size	Installed Copper Distribution Cost	Labor Content Affected	Investment Affected per Foot
2,400	$25.00	0.164	$4.10
1,800	$20.00	0.164	$3.28
1,200	$15.00	0.164	$2.46
900	$12.50	0.164	$2.05
600	$10.00	0.164	$1.64
400	$7.50	0.164	$1.23
200	$5.30	0.164	$0.87
100	$3.15	0.164	$0.52
50	$2.05	0.164	$0.34
25	$1.50	0.164	$0.25
12	$0.95	0.164	$0.16
6	$0.80	0.164	$0.13

Application of Regional Labor Adjustment Factor on Copper Feeder Cable Installation			
Copper Feeder Cable Size	Installed Copper Feeder Cost	Labor Content Affected	Investment Affected per Foot
4,200	$29.00	0.164	$4.76
3,600	$26.00	0.164	$4.26
3,000	$23.00	0.164	$3.77
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41

Application of Regional Labor Adjustment Factor on Fiber Feeder Cable Installation				
Fiber Feeder Cable Size	Installed Fiber Feeder Cost	Labor Content Affected	Factor	Investment Affected per Foot
216	$13.10	$2.00	0.364	$0.73
144	$9.50	$2.00	0.364	$0.73
96	$7.10	$2.00	0.364	$0.73
72	$5.90	$2.00	0.364	$0.73
60	$5.30	$2.00	0.364	$0.73
48	$4.70	$2.00	0.364	$0.73
36	$4.10	$2.00	0.364	$0.73
24	$3.50	$2.00	0.364	$0.73
18	$3.20	$2.00	0.364	$0.73
12	$2.90	$2.00	0.364	$0.73

Application of Regional Labor Adjustment Factor on Outdoor SAI Installation			
Outdoor SAI Total Pairs Terminated	Installed Outdoor SAI	Labor Content Affected	Investment Affected per Outdoor SAI
7,200	$10,000	0.164	$1,640
5,400	$8,200	0.164	$1,345
3,600	$6,000	0.164	$984
2,400	$4,300	0.164	$705
1,800	$3,400	0.164	$558
1,200	$2,400	0.164	$394
900	$1,900	0.164	$312
600	$1,400	0.164	$230
400	$1,000	0.164	$164
200	$600	0.164	$98
100	$350	0.164	$57
50	$250	0.164	$41

Application of Regional Labor Adjustment Factor on Indoor SAI Installation			
Indoor SAI Distribution Cable Size	Installed Indoor SAI	Labor Content Affected	Investment Affected per Indoor SAI
7,200	$3,456	0.164	$567
5,400	$2,592	0.164	$425
3,600	$1,728	0.164	$283
2,400	$1,152	0.164	$189
1,800	$864	0.164	$142
1,200	$576	0.164	$94
900	$432	0.164	$71
600	$288	0.164	$47
400	$192	0.164	$31
200	$96	0.164	$16
100	$48	0.164	$8
50	$48	0.164	$8

Telco Installation & Repair labor (Drop & NID installation): Regional Labor Adjustment Factor applies to $20 of the $35 loaded labor rate (exclusive of exempt material loadings).

Application of Regional Labor Adjustment Factor on NID Installation			
Type of NID	NID Basic Labor	Labor Content Affected	Investment Affected per NID
Residence	$15.00	0.571	$8.57
Business	$15.00	0.571	$8.57

Application of Regional Labor Adjustment Factor on Aerial Drop Installation			
Density Zone	Installed Aerial Drop	Labor Content Affected	Investment Affected per Drop
0-5	$23.33	0.571	$13.33
5-100	$23.33	0.571	$13.33
100-200	$17.50	0.571	$10.00
200-650	$17.50	0.571	$10.00
650-850	$11.67	0.571	$6.67
850-2,550	$11.67	0.571	$6.67
2,550-5,000	$11.67	0.571	$6.67
5,000-10,000	$11.67	0.571	$6.67
10,000+	$11.67	0.571	$6.67

Application of Regional Labor Adjustment Factor on Buried Drop Installation			
Density Zone	Installed Buried Drop per Foot	Labor Content Affected	Investment Affected per Drop
0-5	$0.60	0.125	$0.075
5-100	$0.60	0.125	$0.075
100-200	$0.60	0.125	$0.075
200-650	$0.60	0.125	$0.075
650-850	$0.60	0.125	$0.075
850-2,550	$0.75	0.125	$0.094
2,550-5,000	$1.13	0.125	$0.141
5,000-10,000	$1.50	0.125	$0.188
10,000+	$5.00	0.125	$0.625

Application of Regional Labor Adjustment Factor on Pole Installation			
Total Pole Investment	Pole Labor	Labor Content Affected	Investment Affected per Pole
$417	$216	0.518	$216

The following chart shows recommended default values for each state.

Regional Labor Adjustment Factor:

Direct Labor costs vary among regions in the United States. A variety of sources can be used for labor adjustment factors.[36] The following statewide labor adjustment factor indexes can be used as default values:

State	Factor[37]
Alaska	1.25
Hawaii	1.22
Massachusetts	1.09
California	1.07
Michigan	1.01
New York	1.00
New Jersey	1.00
Rhode Island	1.00
Illinois	1.00
Minnesota	0.99
Connecticut	0.98
Pennsylvania	0.97
Nevada	0.95
Washington (State)	0.92
Oregon	0.92
Delaware	0.92
Indiana	0.92
Missouri	0.90
Maryland	0.89

[36] See, for example, R.S. Means Company, Inc., *Square Foot Costs, 18th Annual Edition,* 1996, p.429-433.

[37] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15. [Normalized for New York State as 1.00]

State	Factor[37]
New Hampshire	0.86
Montana	0.85
West Virginia	0.84
Ohio	0.83
Wisconsin	0.83
Arizona	0.81
Colorado	0.77
New Mexico	0.76
Vermont	0.75
Iowa	0.74
North Dakota	0.74
Idaho	0.73
Maine	0.73
Kentucky	0.73
Louisiana	0.72
Kansas	0.71
Utah	0.71
Tennessee	0.70
Oklahoma	0.69
Florida	0.68
Virginia	0.67
Nebraska	0.65
Texas	0.65
South Dakota	0.64
Georgia	0.62
Arkansas	0.61
Wyoming	0.60
Alabama	0.58
Mississippi	0.58
South Carolina	0.55
North Carolina	0.51

APPENDIX A

Interoffice Transmission Terminal Configuration (OC-3 Fiber Ring)

```
                        ┌──────────┐
   OC-3 Ring  ////      │   OC-3   │      ////  OC-3 Ring
                        │   ADM    │
                        └────┬─────┘
                             │
              ┌──────────────┴───────────────┐
              │  Digital Cross Connect System │
              └──┬──────────────┬──────────┬──┘
                 │              │          │
            ┌────┴────┐    Special    ┌────┴────┐
            │  DS-1   │    Access     │   EO    │
            │  MUX    │    (DLC)      │ Switch  │
            └────┬────┘               └─────────┘
                 │
             Special
             Access
             (Non- DLC)
```
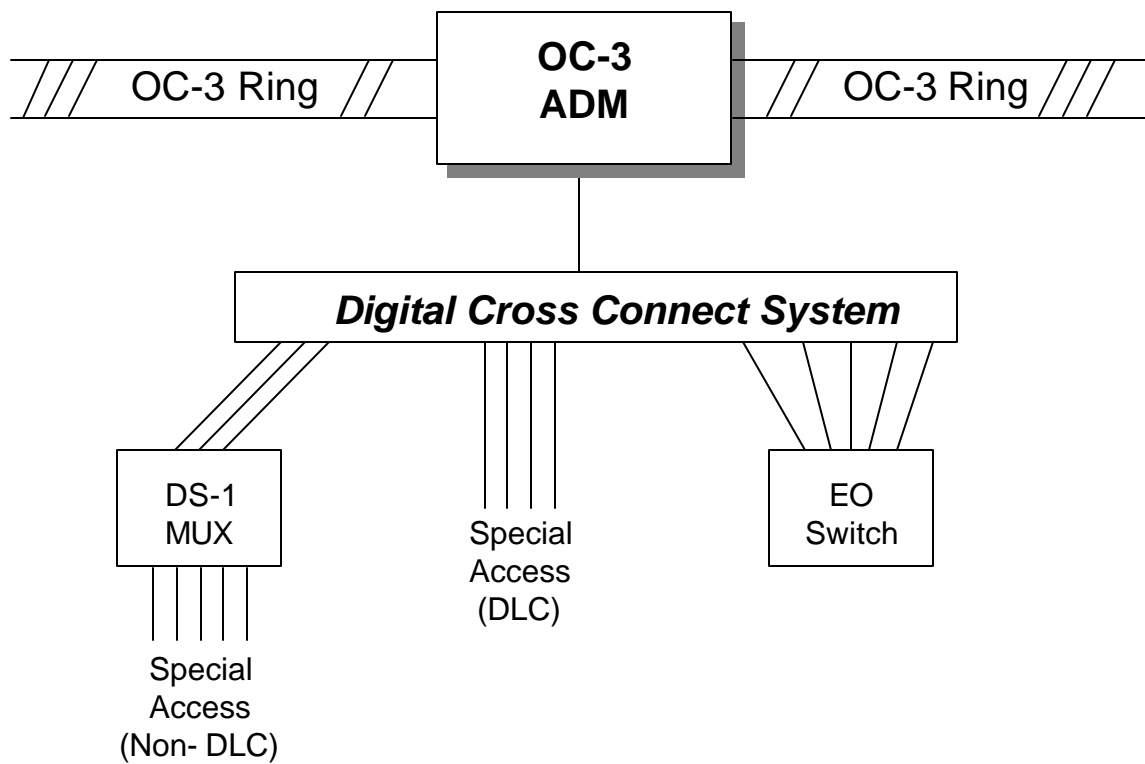
Interoffice Transmission Terminal Configuration (OC-48 Fiber Ring)

```
        ┌─────────┐
//|//|  │ OC-48   │  //|//
OC-48 Ring │  ADM  │  OC-48 Ring   //|
//|//|  └─────────┘
```

OC-48 Ring   OC-48 Ring

OC-48 ADM

OC-3 MUX   OC-3 MUX   OC-3 MUX

Digital Cross Connect System

DS-1 MUX

EO Switch

Special Access (Non-DLC)

Special Access (DLC)
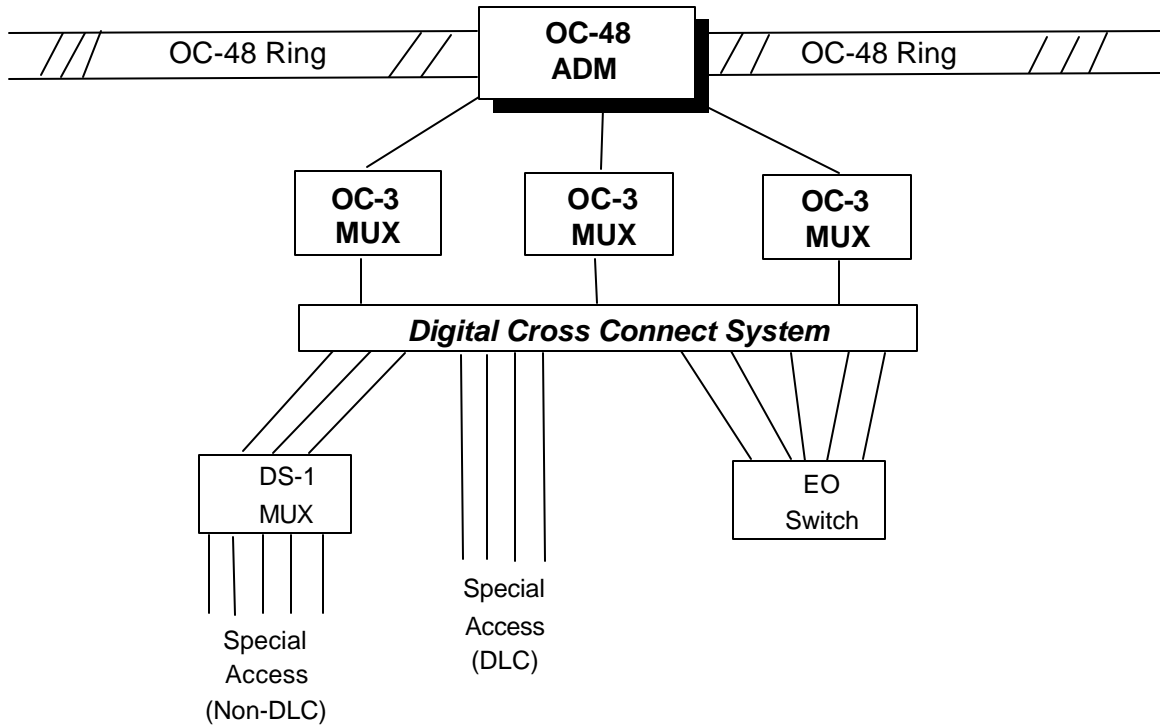
APPENDIX B

Structure Shares Assigned to Incumbent Local Telephone Companies

B.1. Overview

Due to their legacy as rate-of-return regulated monopolies, LECs and other utilities have heretofore had little incentive to share their outside plant structure with other users. To share would have simply reduced the "ratebase" upon which their regulated returns were computed. But today and going forward, LECs and other utilities face far stronger economic and institutional incentives to share outside plant structure whenever it is technically feasible. There are two main reasons. First, because utilities are now more likely to either face competition or to be regulated on the basis of their prices (e.g., price caps) rather than their costs (e.g., ratebase), a LEC's own economic incentive is to share use of its investment in outside plant structure. Such arrangements permit the LEC to save substantially on its outside plant costs by spreading these costs across other utilities or users. Second, many localities now strongly encourage joint pole usage or trenching operations for conduit and buried facilities as a means of minimizing the unsightliness and/or right-of-way congestion occasioned by multiple poles, or disruptions associated with multiple trenching activities.

Because of these economic and legal incentives, not only has structure sharing recently become more common, but its incidence is likely to accelerate in the future – especially given the Federal Telecommunications Act's requirements for nondiscriminatory access to structure at economic prices.

The degree to which a LEC can benefit from structure sharing arrangements varies with the type of facility under consideration. Sharing opportunities are most limited for multiple use of the actual conduits (e.g., PVC pipe) through which cables are pulled that comprise a portion of underground structure. Because of safety concerns, excess ILEC capacity within a conduit that carries telephone cables can generally be shared only with other low-voltage users, such as cable companies, other telecommunications companies, or with municipalities or private network operators. Although the introduction of fiber optic technology has resulted in slimmer cables that have freed up extra space within existing conduits, and thus enlarged actual sharing opportunities, the HAI Model does not assume that conduit is shared because as a forward-looking model of efficient supply, it assumes that a LEC will not overbuild its conduit so as to carry excess capacity available for sharing.

Trenching costs of conduit, however, account for most of the costs associated with underground facilities – and LECs can readily share these costs with other telecommunications companies, cable companies, electric, gas or water utilities, particularly when new construction is involved. Increased CATV penetration rates and accelerated facilities based entry by CLECs into local telecommunications markets will expand further future opportunities for underground structure sharing. In addition, in high density urban areas, use of existing underground conduit is a much more economic alternative than excavating established streets and other paved areas.

Sharing of trenches used for buried cable is already the norm, especially in new housing subdivisions. In the typical case, power companies, cable companies and LECs simply place their facilities in a common trench, and share equally in the costs of trenching, backfilling and surface repair. Gas, water and sewer companies may also occupy the trench in some localities. Economic and regulatory factors are likely to increase further incentives for LECs to schedule and perform joint trenching operations in an efficient manner.

Aerial facilities offer the most extensive opportunities for sharing. The practice of sharing poles through joint ownership or monthly lease arrangements is already widespread. Indeed, the typical pole carries the facilities of at least three potential users – power companies, telephone companies and cable companies. Power companies and LECs typically share the ownership of poles through either cross-lease or

condominium arrangements, or through other arrangements such as one where the telephone company and power company each own every other pole. Cable companies have commonly leased a portion of the pole space available for low voltage applications from either the telephone company or the power company. Methods of setting purchase prices and of calculating pole attachment rates generally are prescribed by federal and state regulatory authorities.

The number of parties wishing to participate in pole sharing arrangements should only increase with the advent of competition in local telecommunications markets. Economic and institutional factors strongly support reliance on pole sharing arrangements. It makes economic sense for power companies, cable companies and telephone companies to share pole space because they are all serving the same customer. Moreover, most local authorities restrict sharply the number of poles that can be placed on any particular right-of-way, thus rendering pole space a scarce resource. The Federal Telecommunications Act reinforces and regulates the market for pole space by prescribing nondiscriminatory access to poles (as well as to conduit and other rights-of-way) for any service provider that seeks access. The aerial distribution share factors displayed below capture a forward-looking view of the importance of these arrangements in an increasingly competitive local market.

B.2. Structure Sharing Parameters

The HAI Model captures the effects of structure sharing arrangements through the use of user-adjustable structure sharing parameters. These define the fraction of total required investment that will be borne by the LEC for distribution and feeder poles, and for trenching used as structure to support buried and underground telephone cables. Since best forward looking practice indicates that structure will be shared among LECs, IXCs, CAPs, cable companies, and other utilities, default structure sharing parameters are assumed to be less than one. Incumbent telephone companies, then, should be expected to bear only a portion of the forward-looking costs of placing structure, with the remainder to be assumed by other users of this structure.

The default LEC structure share percentages displayed below reflect most likely, technically feasible structure sharing arrangements. For both distribution and feeder facilities, structure share percentages vary by facility type to reflect differences in the degree to which structure associated with aerial, buried or underground facilities can reasonably be shared. Structure share parameters for aerial and underground facilities also vary by density zone to reflect the presence of more extensive sharing opportunities in urban and suburban areas. In addition, LEC shares of buried feeder structure are larger than buried distribution structure shares because a LEC's ability to share buried feeder structure with power companies is less over the relatively longer routes that differentiate feeder runs from distribution runs. This is because power companies generally do not share trenches with telephone facilities over distances exceeding 2500 ft.[38]

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[38] A LEC's sharing of trenches with power companies, using random separation between cables for distances greater than 2,500 feet requires that either the telecommunications cable have no metallic components (i.e., fiber cable), or that both companies follow "Multi-Grounded Neutral" practices (use the same connection to earth ground at least every 2,500 feet).

Default Values in HM 5.0a

Structure Percent Assigned to Telephone Company						
	Distribution			Feeder		
Density Zone	Aerial	Buried	Under-ground	Aerial	Buried	Under-ground
0-5	.50	.33	1.00	.50	.40	.50
5-100	.33	.33	.50	.33	.40	.50
100-200	.25	.33	.50	.25	.40	.40
200-650	.25	.33	.50	.25	.40	.33
650-850	.25	.33	.40	.25	.40	.33
850-2,550	.25	.33	.33	.25	.40	.33
2,550-5,000	.25	.33	.33	.25	.40	.33
5,000-10,000	.25	.33	.33	.25	.40	.33
10,000+	.25	.33	.33	.25	.40	.33

B.3. Support

Actual values for the default structure sharing parameters were determined through forward-looking analysis as well as assessment of the existing evidence of structure sharing arrangements. Information concerning present structure sharing practices is available through a variety of sources, as indicated in the references to this section. The HM 5.0a estimates of best forward-looking structure shares have been developed by combining this information with expert judgments regarding the technical feasibility of various sharing arrangements, and the relative strength of economic incentives to share facilities in an increasingly competitive local market. The reasoning behind the HAI Model's default structure sharing parameters is described below.

Aerial Facilities:

As noted in the overview to this section, aerial facilities (poles) are already a frequently shared form of structure, a fact that can readily be established through direct observation. For all but the two lowest density zones, the HAI Model uses default aerial structure sharing percentages that assign 25 percent of aerial structure costs to the incumbent telephone company. This assignment reflects a conservative assessment of current pole ownership patterns, the actual division of structure responsibility between high voltage (electric utility) applications and low voltage applications, and the likelihood that incumbent telephone companies will share the available low voltage space on their poles with additional attachers.[39]

ILECs and Power Companies generally have preferred to operate under "joint use," "shared use," or "joint ownership" agreements whereby responsibility for poles is divided between the ILEC and the power company, both of whom may benefit from the presence of third party attachers. New York Telephone

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[39] This sharing may be either of unused direct attachment space on the pole, or via co-lashing of other users' low voltage cables to the LEC's aerial cables. See, Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

reports, for example, that almost 63 percent of its pole inventory is jointly owned,[40] while, in the same proceeding, Niagara Mohawk Power Company reported that 58 percent of its pole inventory was jointly owned[41]. Financial statements of the Southern California Joint Pole Committee indicate that telephone companies hold approximately 50 percent of pole units[42]. Although proportions may vary by region or state, informed opinion of industry experts generally assign about 45 percent of poles to telephone companies. Note that both telephone companies and power companies may lease space on poles solely owned by the other.

While the responsibility for a pole may be joint, it is typically not equal. Because a power company commonly needs to use a larger amount of the space on the pole to ensure safe separation between its conductors that carry currents of different voltages (e.g., 440 volt conductors versus 220 volt conductors) and between its wires and the wires of low voltage users, the power company is typically responsible for a larger portion of pole cost than a telephone company.

Because of the prevalence of joint ownership, sharing, and leasing arrangements, it is unusual for a telephone company to use poles that are not also used by a power company. ILEC structure costs are further reduced by the presence of other attachers in the low voltage space. Perhaps the best example is cable TV. Rather than install their own facilities, CATV companies generally have leased low voltage space on poles owned by the utilities. Thus, the ILECs have been able to recover a portion of the costs of their own aerial facilities through pole attachment rental fees paid by the CATV companies. The proportion of ILEC aerial structure costs recoverable through pole attachment fees is now likely to increase still further as new service providers enter the telecommunications market.

As noted above, the other, most obvious reason for assigning a share of aerial structure costs as low as 25 percent to the ILEC is the way that the space is used on a pole. HM 5.0a assumes that ILECs install the most commonly placed pole used for joint use, a 40 foot, Class 4 pole.[43] Of the usable space on such a pole, roughly half is used by the power company which has greater needs for intercable separation. That leaves the remaining half to be shared by low voltage users, including CATV companies and competing telecommunications providers.

Thus, a) because ILECs generally already bear well less than half of aerial structure costs; b) because ILECs now face increased opportunities and incentives to recover aerial facilities costs from competing local service providers; c) because new facilities-based entrants will be obliged to use ILEC-owned structure to install their own networks; and, d) because the Telecommunications Act requires ILECs to provide nondiscriminatory access to structure as a means of promoting local competition, on a forward-looking basis, it is extremely reasonable to expect that ILECs will need, on average, to bear as little as 25 percent of the total cost of aerial structure.

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[40] New York Telephone's Response to Interrogatory of January 22, 1997, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

[41] Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997. These experts also predicted that sharing of poles among six attachers would not be uncommon.

[42] " Statement of Joint Pole Units and Annual Pole Unit Changes by Regular Members", Monthly Financial Statements of the Southern California Joint Pole Committee, October, 1996.

[43] Opinion of engineering team. Also, "The Commission {FCC} found that 'the most commonly used poles are 35 and 40 feet high, ...'" {FCC CS Docket No. 97-98 NPRM dtd 3/14/97 pg. 6, and 47 C.F.R. § 1.1402(c). A pole's "class" refers to the diameter of the pole, with lower numbers representing larger diameter poles.

Buried Facilities:

Buried structure sharing practices are more difficult to observe directly than pole sharing practices. Some insight into the degree to which buried structure is, and will be shared can be gained from prevailing municipal rules and architectural conventions governing placement of buried facilities. As mentioned in the overview, municipalities generally regulate subsurface construction. Their objectives are clear: less damage to other subsurface utilities, less cost to ratepayers, less disruption of traffic and property owners, and fewer instances of deteriorated roadways from frequent excavation and potholes.

Furthermore, since 1980, new subdivisions have usually been served with buried cable for several reasons. First, prior to 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety related reasons. Contacts with telephone outside plant engineers, architects and property developers in several states confirm that in new subdivisions, builders typically not only prefer buried plant that is capable of accommodating multiple uses, but they usually dig the trenches at their own expense, and place power, telephone, and CATV cables in the trenches, if the utilities are willing to supply the materials. Thus, many buried structures are available to the LEC at no charge. The effect of such "no charge" use of developer-dug trenches reduces greatly the effective portion of total buried structure cost borne by the LEC. Note, too, that because power companies do not need to use a disproportionately large fraction of a trench – in contrast to their disproportionate use of pole space, and because certain buried telephone cables are plowed into the soil rather than placed in trenches, the HM 5.0a assumed LEC share of buried structure generally is greater than of aerial structure.

Facilities are easily placed next to each other in a trench as shown below:
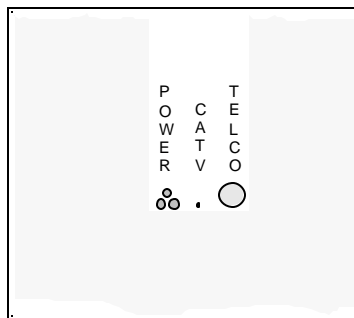
Underground Facilities:

Underground plant is generally used in more dense areas, where the high cost of pavement restoration makes it attractive to place conduit in the ground to permit subsequent cable reinforcement or replacement, without the need for further excavation. Underground conduit usually is the most expensive investment per foot of structure -- with most of these costs attributable to trenching. For this reason alone, it is the most attractive for sharing.

In recent years, major cities such as New York, Boston, and Chicago have seen a large influx of conduit occupants other than the local telco. Indeed most of the new installations being performed today are cable placement for new telecommunications providers. As an example, well over 30 telecommunications providers now occupy ducts owned by Empire City Subway in New York City.[44] This trend is likely to continue as new competitors enter the local market.

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[44] Empire City Subway is the subsidiary of NYNEX that operates its underground conduits in New York City.

References

Industry experience and expertise of HAI

The knowledge of AT&T and MCI outside plant engineers.

Outside Plant Consultants

Montgomery County, MD Subdivision Regulations

Policy Relating to Grants of Location for New Conduit Network for the Provision of Commercial Telecommunications Services

Monthly Financial Statements of the Southern California Joint Pole Committee.

Conversations with representatives of local utility companies.

New York Telephone's Response to Interrogatory of January 22, 1997, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

"Statement of Joint Pole Units and Annual Pole Unit Changes by Regular Members", Monthly Financial Statements of the Southern California Joint Pole Committee, October 1996.

APPENDIX C

Expenses in HAI Model 5.0

Expense Group: Network Expenses
Explanation: Maintenance and repair of various categories of investment - outside plant (e.g., NID, drop, distribution, Service Area Interface, Circuit equipment, Feeder plant) and Central office equipment (e.g., switch)
Data Origin: New England Telephone Company Incremental Cost Study (switching and circuit operating expenses), HAI Consultant (NID), FCC 1996 ARMIS 43-03 (everything else).

> 6212 Digital Electronic Expense
> 6230 Operator Systems Expense
> 6232 Circuit Equipment Expense
> 6351 Public
> 6362 Other Terminal Equipment
> 6411 Poles
> 6421 Aerial Cable
> 6422 Underground Cable
> 6423 Buried Cable
> 6426 Intrabuilding Cable
> 6431 Aerial Wire
> 6441 Conduit Systems

Amount Determination: Expense-to-Investment ratio (NET Study, ARMIS); Dollar per Line for NID.
Application: Determine cost by multiplying Expense-to-Investment ratio times modeled investments; Determine NID cost by multiplying Dollar-per-Line times number of lines

Expense Group: Network Operations
Explanation: Network related expenses needed to manage the network but not accounted for on a plant type specific basis
Data Origin: 1996 ARMIS 43-03

> 6512 Provisioning Expenses
> 6531 Power Expenses
> 6532 Network Administration
> 6533 Testing
> 6534 Plant Operations Administration
> 6535 Engineering

Amount Determination: HAI default Network Operations Factor 50% times the embedded amount in ARMIS.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to UNE direct costs. Cost of "Network Administration" is allocated to traffic sensitive (i.e., switching, signaling and interoffice) UNEs only.

Expense Group: Network Support and Miscellaneous
Explanation: Miscellaneous expenses needed to support day to day operations
Data Origin: 1996 ARMIS 43-03

6112 Motor Vehicles	HAI: Network Support
6113 Aircraft	HAI: Network Support
6114 Special Purpose Vehicles	HAI: Miscellaneous
6116 Other Work Equipment	HAI: Miscellaneous

Amount Determination: In essence, embedded ARMIS levels are scaled to reflect the relative change in either cable and wire (C&W) investment for Network Support Expenses or total investment for Miscellaneous Expenses in the modeled results versus ARMIS. For example:

HAI Cost

= Embedded ARMIS Expense x (HAI C&W Inv./ARMIS C&W Inv.)

The rationale is that these costs will be lower in a forward-looking cost study.

Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs

Expense Group: Other Taxes

Explanation: Taxes paid on gross receipts and property (i.e., 7240 Other Operating Taxes)

Data Origin: HAI expert estimate of 5% is based on overall Tier 1 Company ratio of ARMIS 7240 Expenses to ARMIS Revenues.

Amount Determination: Modeled costs are grossed up by 5%.

Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Miscellaneous

Explanation: Miscellaneous expenses needed to support day to day operations

Data Origin: 1996 ARMIS 43-03

      6122 Furniture

      6123 Office Equipment

      6124 General Purpose Computer

      6121 Buildings

Amount Determination: In essence, embedded ARMIS levels are scaled to reflect the relative change in total investment in the HAI model versus ARMIS. For example:

HAI Cost

= Embedded ARMIS Expense x (HAI Tot. Inv./ARMIS Tot. Inv.)

The rationale is that these costs will be lower in a forward-looking cost study.

Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Carrier-to-carrier customer service

Explanation: This category includes all carrier customer-related expenses such as billing, billing inquiry, service order processing, payment and collections. End-user retail services are not included in UNE cost development.

Data Origin: 1996 ARMIS 4304 (carrier-to-carrier cost to serve IXC access service)

      7150 Service Order Processing

      7170 Payment and Collections

      7190 Billing Inquiry

      7270 Carrier Access Billing System

Amount Determination: HAI multiplies embedded amount (across Tier 1 LECs) times 70% to get $1.69 per line per year. The cost is determined by multiplying the cost per line times the number of lines. This figure includes the above business office activities, hence there is no need for a separate non-recurring charge to account for this activities. The underlying data that the UNE costs were developed from include other types of non-recurring costs outside the business office. Most of the non-recurring costs are captured in the HAI UNE estimate.

Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Variable Overhead

Explanation: Executive, Planning and General and Administrative costs

Data Origin: 1996 ARMIS 43-03

  6711 Executive
  6712 Planning
  6721 Accounting & Finance
  6722 External Relations
  6723 Human Resources
  6724 Information Management
  6725 Legal
  6726 Procurement
  6727 Research & Development
  6728 Other General & Administrative

Amount Determination: HAI estimates 10.4% multiplier based on AT&T public data.

		$Mill	Source
A	Rev. Net of Settlements	36,877	Form M 1994
B	Settlement Payout	4,238	Intl Traffic Data, 1994 data
C	Gross Revenues	41,115	A + B
D	Corporate Operations	3,879	Form M 1994
E	Revenue less Corp. Op.	37,236	C - D
F	Ratio	10.4%	D/E

Application: Cost is determined by multiplying the sum of all costs by 1.104.

Expense Group: Carrier-to-carrier Uncollectibles

Explanation: Revenues not realized associated with services provided (i.e., delinquency, fraud)

Data Origin: Company-specific ratio calculated from 1996 ARMIS 4304 Uncollectibles to 1996 ARMIS Access Revenues.

Amount Determination: Modeled costs are grossed up by the uncollectible rate.

Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

APPENDIX D

Network Operations Reduction

No matter what area of network operations one looks at, one observes a rich set of target opportunities for cost savings. In Account 6512, Network Provisioning, new technologies such as the Telecommunications Management Network (TMN) standards, procedures, and systems, and Digital Cross-Connect Systems (DCS) provide for much more centralized access and control, and self-provisioning by customers (including, and especially, knowledgeable CLECs). Given the tiered nature of TMN, where there are element, network, service, and business layers of management, some of the advantages of TMN will redound to the benefit of plant-specific expenses, while others, associated with the network, service and business management layers, will benefit the more-general activities included in network operations
The use of Electronic Data Interchange, intranet technology, and technologies such as bar coding provide substantial opportunities to reduce the costs of the inventory component of this category of accounts. On the human resources side, there is a greater emphasis on quality control in provisioning activities, reducing incipient failures in the services and elements provided.

As far as power expenses, Account 6531, digital components typically consume less power than their analog counterparts. Furthermore, centralization in other expense categories also spills over into this category, since centralization implies fewer buildings to power less of the time. Finally, due to the onset of competition in the electric power industry and the greater regulatory scrutiny of new generation resources, the industry is increasingly willing to provide price reductions to large business (and, increasingly, even residential and small business) customers. It is now quite common for firms to participate in energy programs in which, in exchange for reducing consumption during peak hours, they receive substantial discounts in the cost of power.

Network Administration, Account 6532, benefits from the deployment of SONET-based transport, because many administration activities are oriented to reacting to outages, which are lessened with the deployment of newer technologies. Testing, Account 6533, also benefits from the better monitoring and reporting capabilities provided by TMN and SONET. This can lead to more proactive, better-scheduled preventative maintenance. On the human resources side, there is a growing tendency for testing activities to be taken over by contractors, leading to lower labor costs for the ILECs. To the extent the activities are still performed by telephone company personnel, they can be performed by personnel with lower job classifications. Finally, the use of "hot spares" can reduce the need for out-of-hours dispatch and emergency restoral activities. Overall, fiber and SONET projects are often "proven in" partly on the assumption that they will produce significant operational savings.

Plant Operations and Administration, Account 6534, is likely to require fewer supervisory personnel, and more involvement by the vendors of equipment to the ILECs. For instance, as vendors take over many of the installation and ongoing maintenance activities associated with their equipment, there will be fewer ILEC engineers requiring management. The use of multi-skilled craft people will allow for fewer specialists to be sent out to address particular problems, and less supervision to manage the people that are sent out. It will, for instance, allow for greater span of control in supervisory and management ranks.

Finally, Engineering, Account 6535, will be more focused on activities associated with positioning the ILECs in a multi-entrant marketplace, less on the engineering of specific elements and services, as those activities become more automated and more in the hands of the purchasers of unbundled elements. To the extent that engineering addresses particular projects, or categories of projects, the use of better planning tools, such as the ability to geocode customer locations and sizes, will act to reduce the amount of such activities.

Additional specific reasons for adjusting the embedded level of these expenses include the following:

<u>Recognize industry trends and the opportunities for further reductions.</u> Network operations expenses, expressed on a per line basis, have already declined over the past several years. For the reasons described in the previous section, this trend is expected to continue as modern systems and technologies are deployed.

<u>Eliminate incumbent LEC retail costs from the network operations expense included in the cost for unbundled network elements.</u> A number of the sub-accounts (6533 Testing and 6534 Plant Operations Administration) include costs that are specific to retail operations that are not appropriately included in the cost calculated for unbundled network elements. A portion of the expenses booked to these sub-accounts represent activities that new entrants, rather than the incumbent LEC, will be performing. Analysis indicates that, as a conservative measure, 20% of the expenses in these two sub-accounts represent such retail activities and should be excluded. Since these two sub-accounts represent 56% of the total booked network operations expense, it is reasonable to conclude that, at a minimum, an additional 11% reduction should be applied to the historic booked levels of network operations expense.

<u>Incorporate incumbent LEC expectations of forward-looking network operations expense levels.</u> The Benchmark Cost Proxy Model ("BCPM"), sponsored by PacTel, Sprint, and US West, consistently calculates a level network operations expense per line that is well below historic levels and below the level calculated by the HAI Model. This projection of forward-looking network operations expenses, prepared for and advocated by three incumbent LECs, indicates that the HAI Model adjustment to the embedded levels of these expenses are appropriate and necessary (and may yield cost estimates that are conservatively high).

<u>Minimize double counting of network operations expenses.</u> A careful review of the way ARMIS account 6530 and the related sub-accounts (6531 Power, 6532 Network Administration, 6533 Testing, 6534 Plant Operations Administration, and 6535 Engineering) are constructed makes it clear that further adjustment is necessary to accurately produce forward-looking costs. Many of the engineering and administrative functions that are included in these accounts are recovered by the incumbent LECs through non-recurring charges. Without such an adjustment, these costs may be double-recovered through existing non-recurring charges and simultaneously through the recurring rates based on the HAI Model results. Similarly, double recovery is possible because these accounts are constructed as so-called "clearance accounts" where expenses are booked before they are assigned to a specific project. Without an adjustment, these expenses could be recovered as service or element-specific costs and as the shared costs represented by network operations expense.

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